DEPARTMENT OF ENERGY FISCAL YEAR 1983 BUDGET ON ENVIRONMENT, HEALTH AND SAFETY

HEARING

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

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[*] On assignment to Budget Committee for 97th Congress.

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DEPARTMENT OF ENERGY FISCAL YEAR 1983 BUDGET ON ENVIRONMENT, HEALTH AND SAFETY

THURSDAY, MARCH 11, 1982

House of Representatives, Committee on Science and Technology, Subcommittee on Natural Resources, Agriculture Research and Environment,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:20 p.m., in room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee) presiding.

Present. Representatives Carney and Sensenbrenner.

Staff present. Dr. James Greene, science consultant; and Maryanne Bach, technical consultant.

Mr. **Scheuer**. The Subcommittee on Natural Resources, Agriculture Research and Environment will come to order.

Today, we begin consideration of the Department of Energy's 1983 budget request for environmental research, environmental safety and environmental health.

We will have a subsequent hearing in which we will examine the impact of the proposed budget cuts and the reorganization of the Department of Energy.

The Congress in its authorization bill established the Agency's fiscal year 1983 funding level for the environmental programs at almost $308 million.

However, the administration has proposed a budget of only $210 million for these programs.

Some of my concerns with this budget would include: One, reduced research on cancer caused by fossil fuel energy technologies; two, reductions in fundings for acid rain research; three, reduced funding for studies on the genetic effects of energy related technology; four, the termination of health risk analysis of all kinds; and finally, five, decreased research in human radiotherapy.

Given these cuts in these high priority areas, I have grave doubts as to whether the Department of Energy can adequately fulfill its responsibilities under Federal environmental statutes, such as the National Environmental Policy Act, at such a reduced funding level. Last year when I voiced these concerns to Secretary Edwards at his appearance before the full Science and Technology Committee, he replied, "We are going to protect the environment to the best of my ability as we move forward and find answers to the energy problems facing this country."

He went on to indicate that the Department would put more emphasis and more funding into environmental research.

These assurances were lacking in 1982. Budget cuts of over 30 percent in these environment and health research programs speak all to plainly to the direction of the Department's research effort.

While all of us, per force, applaud efforts to eliminate unnecessary and duplicative spending programs, many of us also feel that the proposed cuts appear to be arbitrary, excessive, and from a cost benefit point of view, without merit, and without justification.

For example, it is not cost effective to reduce research into the environmental impacts of synthetic fuel and the related technology, when our country is embarked on a crash program to rid ourselves on dependence of Persian Gulf oil. It is also not cost effective to convert stationary energy users from oil and gas to coal, if, the synthetic coal plant when it becomes operative, has to be closed or drastically modified because of its environmentally polluting effects. This is bolting the stable door after the horse has fled and is a very expensive and foolish matter.

It seems absolutely beyond question to us that in a massive energy conversion program that involves spending literally hundreds of billions of dollars, we should also spend a few percent of that money, up front, investigating the environment implications of coal conversion and synthetic fuels. The implications to health and safety seems utterly aberational and unprofessional to us.

We have the burden of preserving the integrity of these programs and we intend to do it.

Today's hearing should provide much of the information needed for us to make these decisions regarding the DOE's environmental programs so, therefore, we are hopeful that they will clarify and answer some of the doubts that we have.

At this time I would like to recognize my distinguished colleague from New York who has been so concerned about many important environment problems and is very supportive of the work of this committee, Congressman William Carney.

Mr. CARNEY. Thank you very much, Mr. Chairman. My remarks will be very brief.

Indeed, the budget cuts are of concern to members of the committee but one must keep in mind the problems that we are faced with as a Nation. We have to keep in mind that when the budget was presented to us just a few short weeks ago we were dealing with one set of figures but external pressures on the economy have even exacerbated those figures more and we have to be very well prepared to make some very very tough cuts in Federal spending. It is not going to be easy.

I might add that as we go forward with this we have to look at what has caused some of our economic woes. Certainly energy has been one of those pressures that have been put upon our economy. The fact is that we were reliant on foreign resources for our energy but now we are taking on some bold initiatives to try and turn that corner. I believe we have done very well to this point and we have to continue to do that. But, when we do do that we have to be concerned about the impact that these new initiatives will have on our environment, on the safety and health of the people of our Nation and the safety and health of the people of the world to be honest about it.

There are many items in this budget that I am not pleased with but I understand the pressures that DOE must deal with in trying to come in with figures that will not continue to exacerbate the budget deficits, which would only be much more harmful to our Nation in the long run than, perhaps, the slowing up of particular programs at this time.

I look forward to the testimony of our witnesses. I am pleased that they are down here in force. I might add that I am sure we will not be able to stump them today, Mr. Chairman. We can get the answers that we so much need to have to make our decisions.

Thank you for the opportunity and I commend you for conducting these hearings today.

Mr. **Scheuer**. Yes, just to clarify our intent, it is not our purpose to stump anybody, it is our purpose to get the information that we need to legislate our authorization legislation, our appropriation legislation intelligently and we are just looking to get answers to our questions. This is not a personal jousting match.

Mr. **Carney**. That was the point I was trying to make.

Mr. **Scheuer**. First, we will hear from Dr. Alvin Trivelpiece, Director of the Office of Energy Research of the Department of Energy. Then, we will hear from Dr. Charles Edington, Associate Director of the Office of Health and Environmental Research.

To both of you, your prepared statements will be printed in full at this point in the record. What I would suggest is that you speak informally for about 10 minutes, perhaps summing up your testimony and then after you have both chatted with us I am sure we will have some questions for you. Since there is only Congressman Carney and myself here today we will keep it informal and we may interrupt you from time to time with an appropriate question.

Take your time now, Dr. Trivelpiece.

STATEMENT OF DR. ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. CHARLES W. EDINGTON, ASSOCIATE DIRECTOR, OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH; AND DELMAR MAYHEW, ACTING DIRECTOR, FINANCIAL MANAGEMENT DIVISION

Dr. **Trivelpiece**. Thank you, Mr. Chairman.

As you have indicated, our prepared statement will be entered into the record and so what I want to do is to begin my testimony by going back to the late 1940's with the creation of the Atomic Energy Commission and then to the enabling legislation that created that organization. I think the founders wisely included a charge and responsibility to see to it that the nuclear activities that were being developed at that time included with them the understaning of the impact of those activities on human health. That was both an offensive strategy and a defensive strategy.

I think it is a defensive strategy in the sense that the people who were doing the work at that time recognized the likelihood that there would be possible detrimental human impact as a result of radiation and in order to bring about a nuclear industry it was going to be necessary for them to understand that in as much detail as possible.

At the same time, it was also offensive. By that I mean that the people who recognized the technology as it existed at that time could clearly see that there were possible human benefits. I think an outstanding example at that time involved the work that had been done by Dr. Lawrence who was the inventor of Cyclotion and for whom the Lawrence Livermore and Lawrence Berkeley laboratories are named.

He had, in fact, during the course of doing research at the laboratory recognized this as a possibility and literally the first patient, to my knowledge, who was ever treated with the radiation was Dr. Lawrence's mother. She had what was believed at that time to have been an inoperable tumor and that tumor was treated by him and his brother using the cyclotion at Berkeley. She went on to live many years as a result of the remission that is assumed to have taken place as a result of that radiation treatment.

That, literally, began the nuclear medicine applications activity in the United States.

The collection of people who were assembled both for the offensive and defensive purposes of understanding radiation and its applications grew in size and it grew in skill to the point that there are now many places in the United States where radiation is routinely used for therapeutic purposes and diagnostic purposes. Each year approximately 37 million people enter hospitals in the United States, to whom over 70 million nuclear medicine procedures are administered. That, obviously, then represents a multimillion dollar industry in the United States and, as such, it returns some fraction of that back to the Federal Treasury in the form of taxes. So, you might ask, "has this been a good idea" and the answer would be "yes, certainly it has been a good idea." Not only has it saved human lives but it has just been plain good business for the United States to have engaged in this activity.

As times changed the AEC grew, and the perceived need at the time to expand the horizons of the Atomic Energy Commission to include other programs led to the folding in of other activities, thus becoming ERDA. So the AEC was combined with other agency activities and became ERDA and then, eventually DOE.

As that transition took place, the need to perform essentially the same kind of offensive and defensive strategy with respect to now, not only nuclear processes, but also chemical processes, led to an expansion of the function of the biological and environmental research and life sciences and nuclear medicine application programs to incorporate studies on toxicological, carcinogenic, mutagenic and teratological impacts of various chemicals and chemical agents that could occur.

The kinds of programs that have grown up have come to involve studies, for example of diesel particles. We learn now that diesel particulate matter is not nearly as harmful as one might have assumed given the known chemical carcinogenic characteristics that it has; biological processes tend to provide a protection for us that might not have been anticipated.

I think it is not too much to say that there proabably are very few people in the world whose lives have not somehow been touched, in one way or another, as an outgrowth of scientific studies that have come directly from the original Atomic Energy Commission program to support biological and environmental research in the life sciences and nuclear medicine. It is a very effective program and I do agree with the chairman's opening remarks: It is an important program and we are here to defend, as best we can, the elements of that program.

Dr. Edington is going to carry on and describe some of the details and specific elements of this program at this time.

[The prepared statement of Dr. Trivelpiece follows:]

Statement of Alvin W. Trivelpiece
Director
Office of Energy Research
Before the
Subcommittee on Natural Resources, Agriculture
Research and Environment
House Committee on Science and Technology
March 11, 1982

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to discuss the FY 1983 budget request for the Biological and Environmental Research (BER), and the General Life Sciences and Nuclear Medicine Applications programs. Although budgeted separately under Energy Supply R&D and General Science and Research, respectively, these programs are managed as an integrated research effort by our Office of Health and Environmental Research (HER). I am accompanied today by Dr. Charles W. Edington, the Director of that office. Dr. Edington will follow my introductory comments with a more detailed discussion of the budget request for these programs. Since Dr. Edington will discuss the budget request in some detail, I would like to focus for a few moments on the role and importance of these programs from an overview perspective.

I believe that our ability to solve our economic and technological problems in this decade and beyond will depend on the scope and depth of our scientific knowledge and on the progress that results from continued support for scientific research programs. From that perspective, I believe that the BER, Life Sciences and Nuclear Medicine programs are important investments in our Nation's future.

As a result of research supported by the BER program we are gaining a better understanding of the ways in which energy-related pollutants affect human health and the environment. More specifically, the BER program supports long-term research to determine the physical and chemical nature of energy-related products and waste material; to identify pollutants that are toxic to humans; to understand how pollutants move through and are changed in the environment; and finally to understand quantitatively how they affect living organisms, including humans. The FY 1983 budget request of $129.8 million for BER reflects a shift in emphasis toward analyzing the long-term generic health and environmental effects of energy production and use, with less emphasis on research related to short-term, single processes.

To understand the effects of pollutants on human health, in particular, we must know more about how human biological systems operate under normal conditions. With this goal in mind, the General Life Sciences program supports research that contributes to our understanding of the complex biological molecules and other components of cells and living systems. In particular, we are trying to learn more about how molecules, cells and subcellular structures are damaged temporarily or permanently by pollutants, and what internal mechanisms exist to repair that damage. The FY 1983 request of $18.8 million for Life Sciences will allow us to continue to develop vital information on the makeup and functions of these biological systems and their components.

With the information developed in the BER and Life Sciences programs, early analyses of biological issues can be carried out in parallel with technological and economic analyses of energy options. I believe that this is a far more productive and cost-effective approach than "after the fact" research and imposition of corrective measures such as retrofits or operating restrictions.

The Nuclear Medicine Applications program, with an FY 1983 budget request of $18.5 million, supports R&D on new ways to use radiation and radioisotopes to diagnose and treat human disease. Although the results of this research do not feed as directly into the technology development process as those of BER and Life Sciences, the Nuclear Medicine program has provided the tools and knowledge to allow diagnosis and treatment of many health problems that would have gone undiagnosed or could only have been handled surgically, if at all, in years past. Nuclear medicine examinations have been and continue to be important in identifying abnormalities of the heart, lungs, kidneys, skeleton, central nervous system and other body organs. This program has been extremely productive over the years in transferring new methods of diagnosis and treatment into medical practice. In fact, the Nuclear Medicine Applications program has produced the technology for what is estimated to be more than 60 million nuclear medicine diagnostic and therapeutic procedures performed annually and has developed most of the diagnostic instrumentation now in use in nuclear medicine.

All of these programs have evolved from the Atomic Energy Commission mandate to develop peaceful uses of nuclear energy, as well as from the expanded environmental responsibilities of the Energy Research and Development Administration for the development of nonnuclear energy. These programs have a significant record of accomplishment. As with any long-term scientific research program, a recitation of only a few research accomplishments, particularly recent ones, often does not convey the true importance and implications of a program. With the perspective of time, however, I believe that the very broad impact of these programs can be seen.

o As a result of some 30 years of HER-supported basic and applied research, the fundamental facts of radiation biology are known and understood. This knowledge provides the basis for setting contemporary radiation protection guidelines and aids in the beneficial use of ionizing radiation and radionuclides in medicine, agriculture and other fields.

o HER programs have been largely responsible for development of many inexpensive short-term tests that allow us to identify toxic chemicals in mixtures containing thousands of compounds. These chemicals can then be eliminated from process materials to which humans might be exposed.

o During the 1960's, research supported by these programs changed our understanding of the damage caused to human systems by radiation. We now know that much of the damage to genetic material caused by ionizing or ultraviolet radiation can be repaired biologically. This research formed the conceptual framework for the development of tests to detect genetic damage that are now used on a world-wide basis. Also, it has now been found that in addition to radiation damage, these repair systems can be applied to genetic damage caused by chemicals.

o The whole field of nuclear medicine that I mentioned earlier was developed as a result of long-term support provided by these programs; and another new field, that of radioecology (i.e., the science dealing with the determination of radionuclide pathways in nature), has been developed. Research in radioecology has led to new insights and breakthroughs in understanding the cycling and fate of selected chemicals through the environment and in the food chain.

All of these accomplishments, and the more recent ones that Dr. Edington will discuss, have two common elements. Their benefits have become evident only over the long-term and were made possible by Federally-supported research. Clearly, industry will carry out the research necessary to comply with Federal and state health and environmental regulations. However, it is both appropriate and necessary for the Federal government to support long-term research on the wide-ranging health and environmental implications of a variety of energy technologies. Federally-sponsored biological research, such as that supported by the HER program, will allow us to compare some of the costs and benefits of technology options and make wise choices.

That concludes my introductory remarks. Dr. Edington will now describe our FY 1983 budget request.

Mr. SCHEUER. Dr. Edington?

Dr. EDINGTON. Thank you, Mr. Chairman. I do not know whether to stop now, based on what Dr. Trivelpiece said, or to continue this discussion.

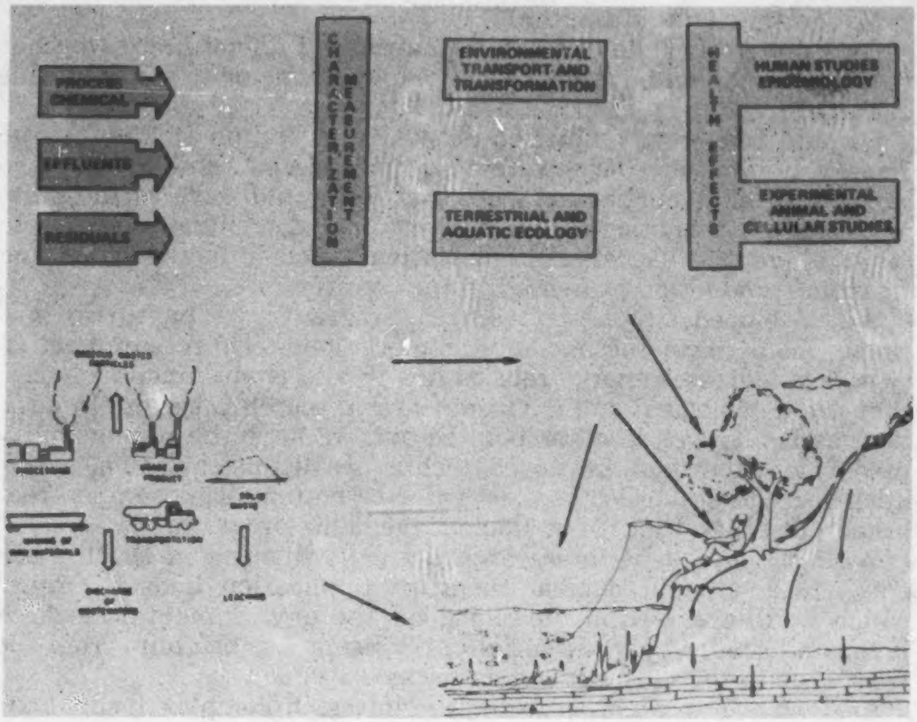
I would like to say that we did have our origin in the Atomic Energy Commission. We were radiation-related totally. We have learned, at that particular time, that we would have to integrate our research activities across a number of disciplines in order to cover all of the aspects that radiation, nuclear technologies and weapons' production presented to the country.

We developed two basic research programs; we have two missions. One is to conduct a comprehensive, long-term research activity which addresses energy-related health and environmental issues; that is our biological and environmental research program. In addition, as Dr. Trevelpiece has pointed out, we have the responsibility to develop new and improved techniques using radiation, radionuclides, and stable isotopes in order to better diagnose and treat human diseases; that is our nuclear medicine program.

We also have a basic research activity which is in the life sciences research and nuclear medicine application budget activity which I will speak to in the biological and environmental research program because they, essentially, represent a continuum from the very basic to the very applied activities.

As I have indicated, in order to address a complex technology, such as a synthetic fuel plant, one has to integrate across disciplines.

If I may have the first viewgraph I will try to give you an indication of how we have done that.



PROCESS CHEMICAL

EFFLUENTS

RESIDUALS

CHARACTERIZATION MEASUREMENT

ENVIRONMENTAL TRANSPORT AND TRANSFORMATION

TERRESTRIAL AND AQUATIC ECOLOGY

HEALTH EFFECTS

HUMAN STUDIES EPIDEMIOLOGY

EXPERIMENTAL ANIMAL AND CELLULAR STUDIES

SLIDE 1

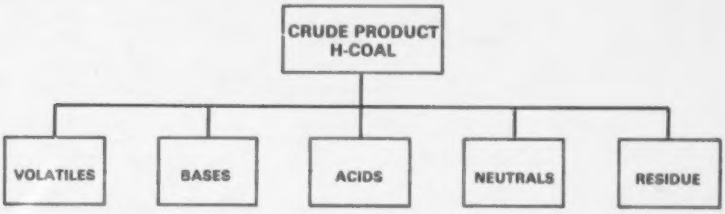
As you know, one must identify a source term: What is being produced at the plant; what is being released to the general environment; what is being released to the occupational environment. In addition, we need to know how much of the material is there and how much of that material is, indeed, toxic.

In order to do that, it is necessary to conduct chemical and biological chgaracterization activities to determine what the chemicals are and determine whether or not they are active biologically.

In addition, one has to understand how that material might be transported through the environmental media, whether it be the atmosphere, the terrestrial or aquatic environments; whether the materials might be transformed into another chemical state and where they go. Where they go becomes very important because we are concerned about the effects on the receptors, the animals and the plants in the environment, the ecological systems as a whole and, in addition, we have a concern about the potential effects on human health.

As you know, to study humans is a very difficult situation. Most of us are exposed to low level of radiation as chemicals. To study low dose effects one requires large populations in order to get statistically valid results, therefore one has to get quantitative information from an experimental animal system in which you can control the variables. You can expose animals to known doses and you can measure quantitatively doses-effect responses.

OFFICE OF HEALTH AND ENVIRONMENTAL RESEARCH
Department of Energy



	VOLATILES	BASES	ACIDS	NEUTRALS	RESIDUE
WEIGHT %	<1.0	3.0	<1.0	95.0	3
TOTAL MUTANTS	0	46,510	0	77,490	0
MUTANTS/MG. (SPECIFIC ACTIVITY)		15.170		815.7	

SLIDE 2

I have given to Mr. Greene, for your use and information, a piece of shale. One can see the dark layers in the shale which represents the kerogen from which one gets the shale oil.

I have also given him a piece of spent shale from which oil has already been extracted. I have also given him a small vial of shale oil, which, perhaps, some of you have never seen before. This is the product of a shale retort facility.

In the shale oil, which I have shown you, there may be several thousand different organic chemical compounds. Our concern is what those compounds are and which one of them are, indeed, biologically active.

In order to do that, we have coupled our chemistry activities and our biological activities together and on this viewgraph, I have indicated that the chemist separates or fractionates that complex material, the crude shale oil or coal liquid, into certain fractions, and then the biologist assays those fractions to determine whether or not any of them is mutagenic.

In this particular situation the Ames test was used. The Ames test is a bacterial system which allowed us to determine whether or not mutation had been produced by any of the fractions.

As you can see there are two fractions; the basic fraction and a neutral fraction which is biologically active. The other three fractions essentially have no activity and we can forget those from the standpoint of biological research.

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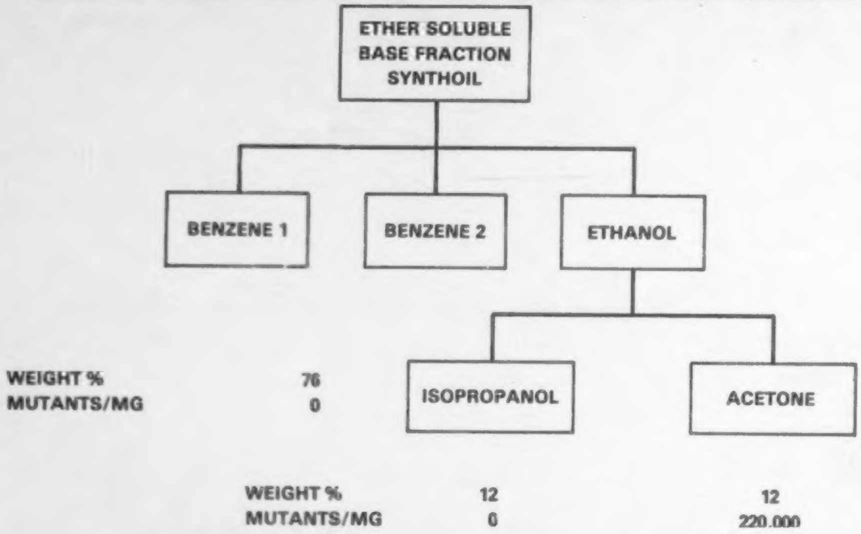
Department of Energy

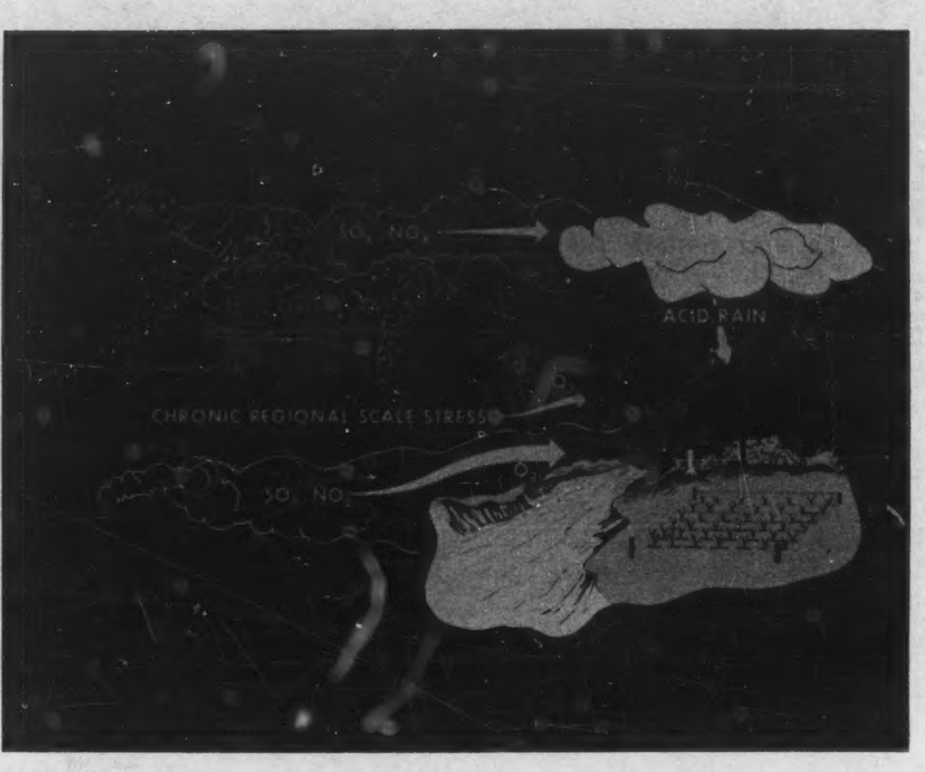

ETHER SOLUBLE
BASE FRACTION
SYNTHOIL
BENZENE 1
BENZENE 2
ETHANOL
ISOPROPANOL
ACETONE
WEIGHT %
MUTANTS/MG
76
0
WEIGHT %
MUTANTS/MG
12
0
12
220.000

SLIDE 3

The next slide will indicate that the chemist has taken one of those fractions and has further fractionated it. As you can see the biological activity has been found in the acetone fraction. Over 90 percent of the biological activity is found in this fraction which represents less than 10 percent of the total weight of the original complex material.

Therefore, we have identified, most of the biological activity in less than 100 chemical compounds as compared to the original starting materials of over 2,000.

These are relative short-term experiments. We have spent the last 3 or 4 years determining the activity in a number of coal liquefaction, coal gasification, and shale retort systems. We are now prepared to turn our attention to longer term experiments in which we are trying to determine the late biological effects of the chemicals in the biologically active fraction.



SLIDE 4

Now that we have identified some of the biologically active materials, we are concerned about their transport. This particular slide is basically aimed at the acid rain problem. I think it represents very clearly what chemical transport, transformation and potential effects might be.

From a coal combustion plant or other fossil energy plant, SO_2, nitrogen oxides and other chemicals are emitted. As they are transported over long distances, they are converted to the sulphates and the nitrates and, eventually, these are deposited either as dry or wet precipitation.

They produce effects. We are still uncertain as to the effect that is produced but it demonstrates very clearly the transport, transformation and ecological effect problem.

Mr. **Sheuer**. Dr. Edington, let me interrupt you here because this problem of acid rain is a problem that this committee has spent many, many days of hearings on. I think we have had 5 or 6 days of hearings. We have had 35 to 40 witnesses and it is a problem that we are deeply concerned about.

I serve with a group of members of the House and the Senate and we have met two or three times with our colleagues from the Canadian Parliament; in fact we just had a meeting about acid rain last weekend, a 4-day meeting. We met with them last year. This subcommittee had a hearing in Lake Placid on acid rain and a number of Canadian parliamentarians along with The Minister of

Environment testified. So, it is something we are very much concerned about. Apparently you are concerned about it, too.

Dr. **Edington**. Yes, sir.

Mr. **Scheuer**. And this great urgency here, the problem of acid rain, whereby we seem to contribute about a half of Canada's acid rain problem—they also contribute about one quarter of our acid rain problem. They have the largest single polluter in the world, Sudbury, with a stack 1,285 feet high. This problem of acid rain is something that is poisoning the relations between Canada and the United States. It is having a devastating effect on their forest growth which accounts for about 17 or 18 percent of their GNP; it is their largest single industry outside of tourism. It has radically affected tourism. Several thousand of their lakes do not support fish life. Two hundred of our Adirondacks lakes do not support fish life. It has had a devastating effect on the whole Adirondacks region.

Do you think there is enough of a very overwhelming body of circumstantial evidence that indicates that acid rain is a serious problem and that some level of controls now over acid rain is justified by the existing body of evidence?

Dr. **Edington**. Mr. Chairman, I share your concern. I think it is an issue that one has to look at. I am not convinced in my own mind that we have enough information to direct us to the source that has to be controlled. I am not convinced of that.

Mr. **Scheuer**. Dr. Edington, we have 17 plants in the Ohio River basin where the prevailing winds go from Southwest to Northeast where apparently the New York State Environment Protection Agency has identified the flow, has identified the fact that the entire east coast is a victim region on these 17 major polluting establishments in the Ohio River basin and that whole region.

The Canadians are certainly convinced of it. There is no doubt about where the sources are. The doubt may be as to whether you can identify a polluting effect in any one particular place one thousand or more miles away as having come from those sources. But, where the pollution comes from we know perfectly well. I am sure we will be hearing from Congressman Sensenbrenner. He represents that area. He is very much involved, very much concerned and very knowledgeable. But, from a point of view of a member in the Northeast who has dealt with the Canadians and has been into this problem, there does not seem to me any question that it is coming from those sources and that it is reeking devastation elsewhere.

Mr. **Sensenbrenner**. Would the chairman yield?

Mr. **Scheuer**. Of course, I will be happy to yield.

Mr. **Sensenbrenner**. Just to set the record straight, Wisconsin is a victim State as is New York in the acid rain problem. The list of allegedly polluting powerplants does not include one powerplant in the State of Wisconsin, which I am very thankful, so I do not represent a substantially different view point than that of the chairman.

Our colleagues from Indiana and Ohio would dispute some of our conclusions, however.

Mr. **Scheuer**. That is right. I did not mean to suggest that you were not very knowledgeable and a very useful member of this committee on this subject as well as many others. That is absolutely true.

We are very concerned about this and we think that some level of control, some level of setting the parameters of acceptable environmental conduct on the part of the utilities and manufacturers is very well justified by the available evidence—imperfect as it may be—and somewhat overdue.

What do you think we should be doing now based on the available body of evidence that has been accrued in terms of beginning some kind of control program directed to acid rain?

Dr. EDINGTON. Well, you are asking me a personal question.

Mr. SCHEUER. No; I am not asking you a personal question. I am asking you as a scientist and a professional who is well versed in these matters and is very knowledgeable.

Dr. EDINGTON. I would like very much, Mr. Chairman, to see an experiment done in which long-range tracers can be used, tracers released at powerplants in the Midwest that could be followed without transformation across the eastern part of the United States into the Northeastern area. We have such a study that is being initiated which is called Captex which is a cross Appalachian transport experiment in which we are using heavy methanes, methane which normally contains carbon and four hydrogen atoms—now has carbon and four deuterium atoms. It weighs more and basically is inert, will travel long distances and can be detected. This kind of an experiment would give us information which would allow us to determine, once and for all, where the polluting materials are coming from. That is my personal opinion.

Mr. SCHEUER. OK. You say that very thoughtfully. Is such a program of tracer identification of sources underway now?

Dr. EDINGTON. That is a program which we are initiating now.

Mr. SCHEUER. That is a long-term program?

Dr. EDINGTON. Long term in the sense that it would be 1 year perhaps, or less.

Mr. SCHEUER. It will take about 1 year?

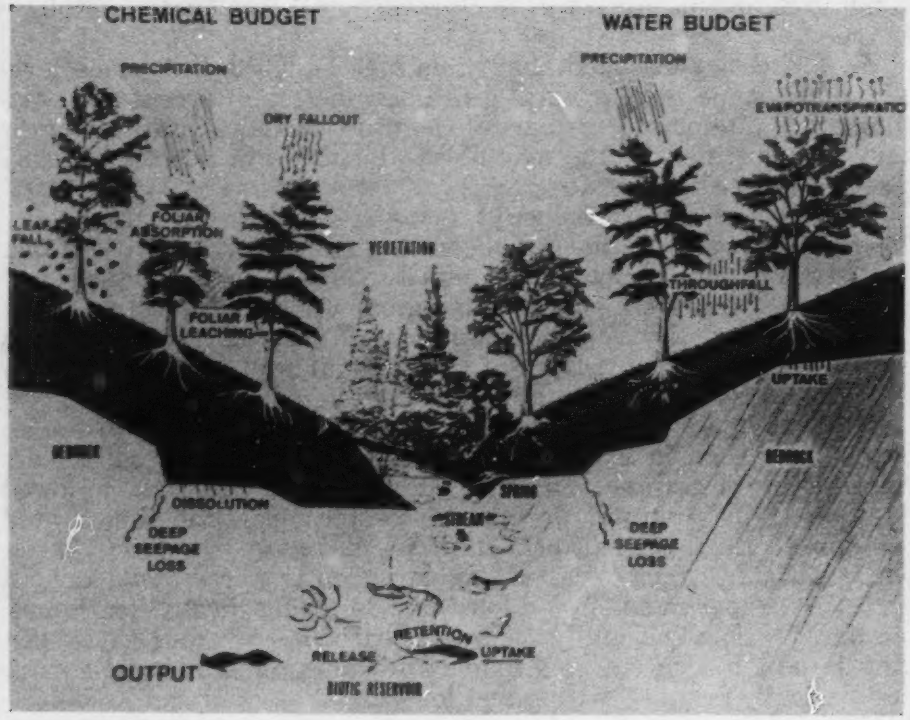
Dr. EDINGTON. Analysis of the data would probably take more time.

Mr. SCHEUER. Do you feel that your agency is requesting sufficient funding to make that a probative program that will produce results on the basis of which Congress could act 1 year from now?

Dr. EDINGTON. That experiment will be conducted within our current budget activity.

Mr. SCHEUER. That is not what I asked. I am asking you as a scientist whether the current budget provisions for funding that program are adequate to give us a reliable knowledge base, a basis on which we would be sound and well justified in acting a year from now depending on what the evidence is. Do you feel that you have adequate funding to provide us with an in-depth knowledge base from which to act a year from now?

Dr. EDINGTON. Yes, sir. I think we do.

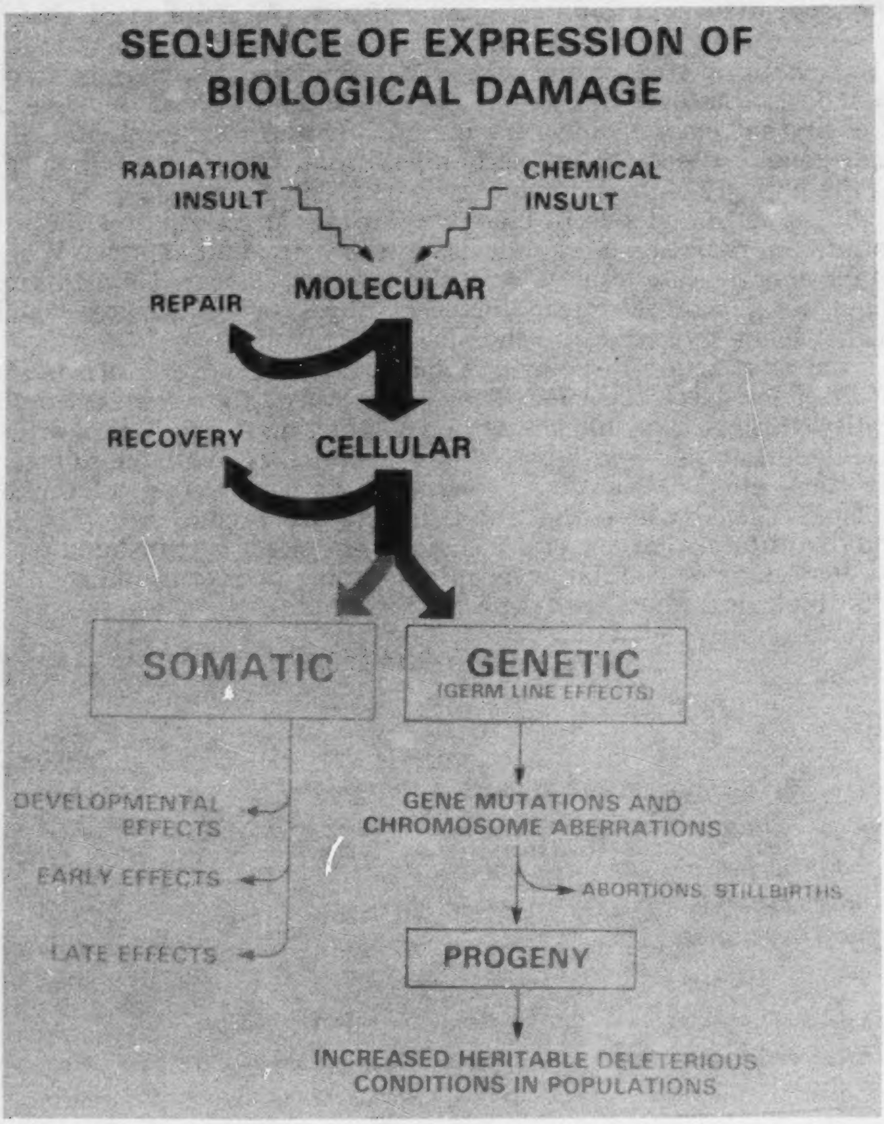

CHEMICAL BUDGET
WATER BUDGET
PRECIPITATION
PRECIPITATION
DRY FALLOUT
EVAPOTRANSPIRATIO
LEAF FALL
FOLIAR ABSORPTION
VEGETATION
FOLIAR LEACHING
THROUGHFALL
UPTAKE
BEDROCK
BEDROCK
DISSOLUTION
SPRING
STREAM
DEEP SEEPAGE LOSS
DEEP SEEPAGE LOSS
RETENTION
RELEASE
UPTAKE
OUTPUT
BIOTIC RESERVOIR

SLIDE 5

Mr. SCHEUER. OK. Please proceed.

Dr. EDINGTON. What I wanted to demonstrate in this particular slide, Mr. Chairman, is the fact that in the Atomic Energy Commission, the first ecological program was developed that was supported by the Federal Government; it was a radioecology program. That program has allowed us to measure in watersheds and other geographical areas, the input of polluting materials or even nonpolluting materials into a watershed, determine the cycling of the material and the uptake of that material by the organisms in the environment which may, indeed, be part of man's food chain.

We are trying to look at the issue from a total situation as opposed to following a specific pollutant. In other words, we are trying to determine what the structure, function, and interaction, of the various components of the ecosystem are and how those pollutants affect that system.



SEQUENCE OF EXPRESSION OF BIOLOGICAL DAMAGE

RADIATION INSULT

CHEMICAL INSULT

MOLECULAR

REPAIR

CELLULAR

RECOVERY

SOMATIC

GENETIC
(GERM LINE EFFECTS)

DEVELOPMENTAL EFFECTS

EARLY EFFECTS

LATE EFFECTS

GENE MUTATIONS AND CHROMOSOME ABERRATIONS

ABORTIONS, STILLBIRTHS

PROGENY

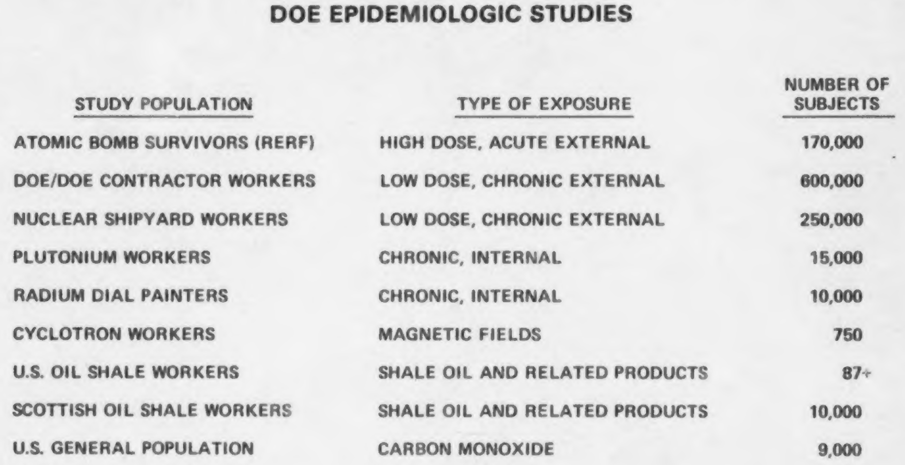
INCREASED HERITABLE DELETERIOUS CONDITIONS IN POPULATIONS

SLIDE 6

As I indicated earlier, one of our major concerns is the effect of energy-related pollutants on human health. As I indicated also, it is very difficult to measure effects on man himself. We have to use a surrogate, in this case experimental animals, they may be mice, rats, dogs, whatever. If one looks at the bottom part of the slide, it is clear that one can measure quantitatively in experimental animals genetic effects; the effect of a pollutnat, radiation or chemical, on the progeny of an individual who has been exposed.

On the left-hand side in blue, we can measure the late effects of pollutants, radiation or chemicals, on the individual exposed. When I talk about a late effect I am talking about cancer, I am talking about developmental effects, or other physiological diseases which might be energy-pollutant related.

I want to hasten to point out, however, that our concern is the effect of low-level exposure. There is no way that we, in all probability, can get that information on a living organism—man, or experimental animal—with the current technology available to measure those effects. Therefore, we have to go back to the cellular or molecular level where the initial effects are produced, determine and quantitate what the effect is, how that effect is translated from the molecular or cellular level into a cancer or into a mutation or other biological effect that is produced in man.



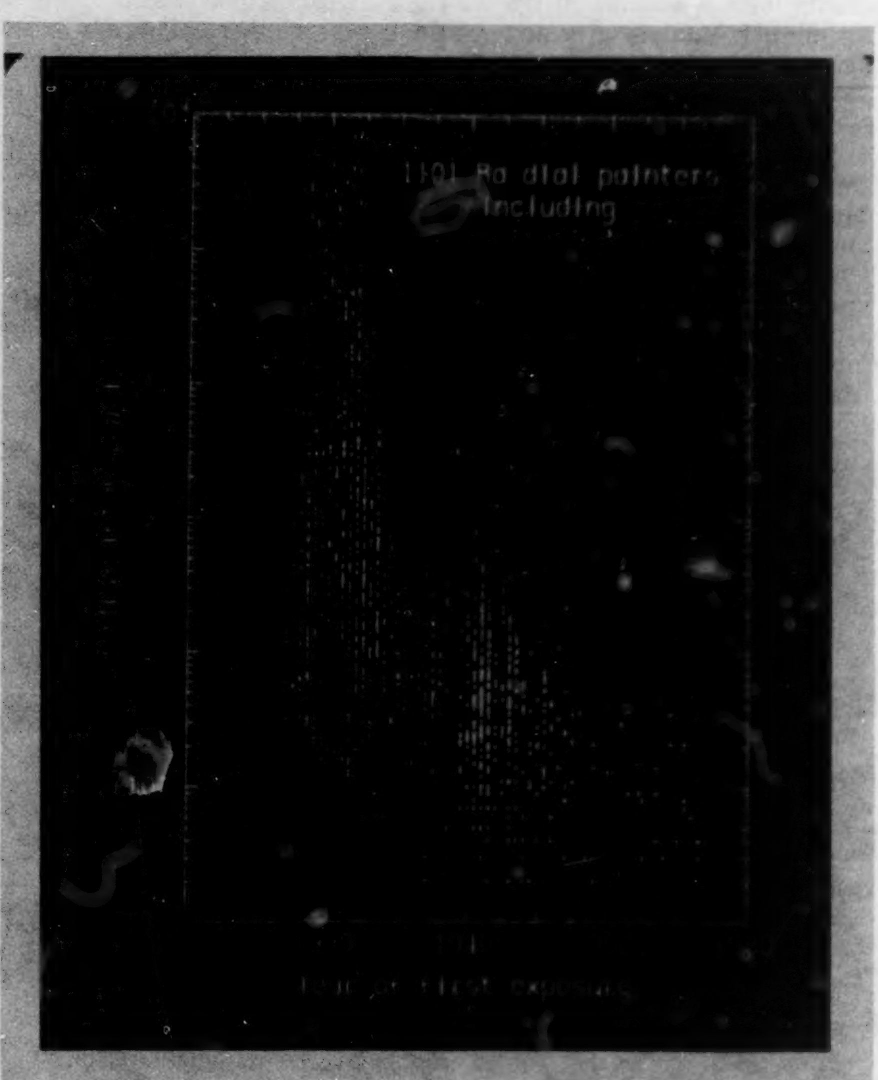
DOE EPIDEMIOLOGIC STUDIES

STUDY POPULATION	TYPE OF EXPOSURE	NUMBER OF SUBJECTS
ATOMIC BOMB SURVIVORS (RERF)	HIGH DOSE, ACUTE EXTERNAL	170,000
DOE/DOE CONTRACTOR WORKERS	LOW DOSE, CHRONIC EXTERNAL	600,000
NUCLEAR SHIPYARD WORKERS	LOW DOSE, CHRONIC EXTERNAL	250,000
PLUTONIUM WORKERS	CHRONIC, INTERNAL	15,000
RADIUM DIAL PAINTERS	CHRONIC, INTERNAL	10,000
CYCLOTRON WORKERS	MAGNETIC FIELDS	750
U.S. OIL SHALE WORKERS	SHALE OIL AND RELATED PRODUCTS	87+
SCOTTISH OIL SHALE WORKERS	SHALE OIL AND RELATED PRODUCTS	10,000
U.S. GENERAL POPULATION	CARBON MONOXIDE	9,000

SLIDE 7

I have indicated that we cannot do experiments on man. I also have to say that there are populations in which exposures to relatively high doses of radiation have occurred, for example, where the population size is reasonably large and one can, indeed, follow those populations. We have tried to maintain support for those studies which are indicated on this slide.

There are five radiation-oriented epidemiology studies and, as you can see, many of them are high-dose, acute exposures, such as the Japanese studies. We have low-dose chronic exposures in the work place and we have internal emitters: radium, plutonium, radionuclides of that type. We are studying the populations who have, essentially, been exposed to these types of radiation. In addition, we have some small studies in nonnuclear activities but they are limited because there are not enough populations of sufficient size to study.



DISTRIBUTION OF RADIUM INTAKES AND RADIUM RELATED MALIGNANCIES FOR 1101 FORMER DIAL PAINTERS.

SLIDE 8

For your information, on the next slide, our radium study is essentially a study that was started several years ago in order to study the radium dial painters; the young ladies who spent their working hours painting radium on watch dials. These individuals, in order to keep a sharp tip on their paint brush would put it in their mouth and as a result would ingest radium. There were 68 individuals in this particular picture. In our study we have been able to follow or to find 55 of those individuals. They have been exposed to relatively high concentrations of radium and in those 55 individuals 11 have demonstrated cancers; 4 had cancer of the bone, and 7 had cancer of the sinus or mastoid areas.

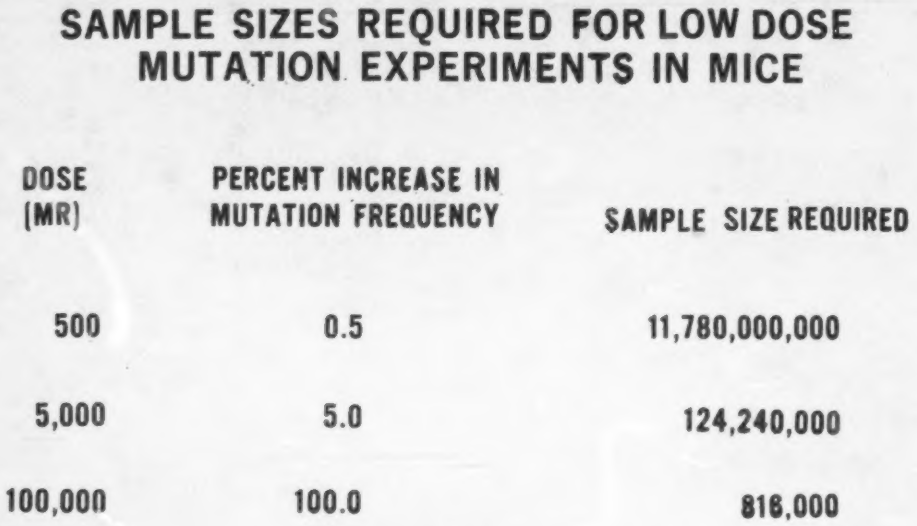
Mr. **Scheuer**. Have those cancers been treatable or were they lethal?

Dr. **Edington**. In most cases, my guess is that these cancers were lethal. We have found them many years after the fact and after the cancer has been established. In some cases it is a posthumous establishment.

Mr. **Scheuer**. Yes.

SLIDE 9

Dr. **Edington**. In this slide I have shown 1,100 radium dial painters who have been followed in our study. In these 1,100 individuals, 56 of the individuals had radium induced tumors. The reason I use this slide is to indicate that the lowest exposure level at which a tumor-related individual is found is several orders of magnitude above the maximum permissible bone uptake of 10 to the minus 1 microcuries of radium. So, it would appear that, in the case of radium, the standards are conservative and, hopefully, this is also true for plutonium and other radionuclides.

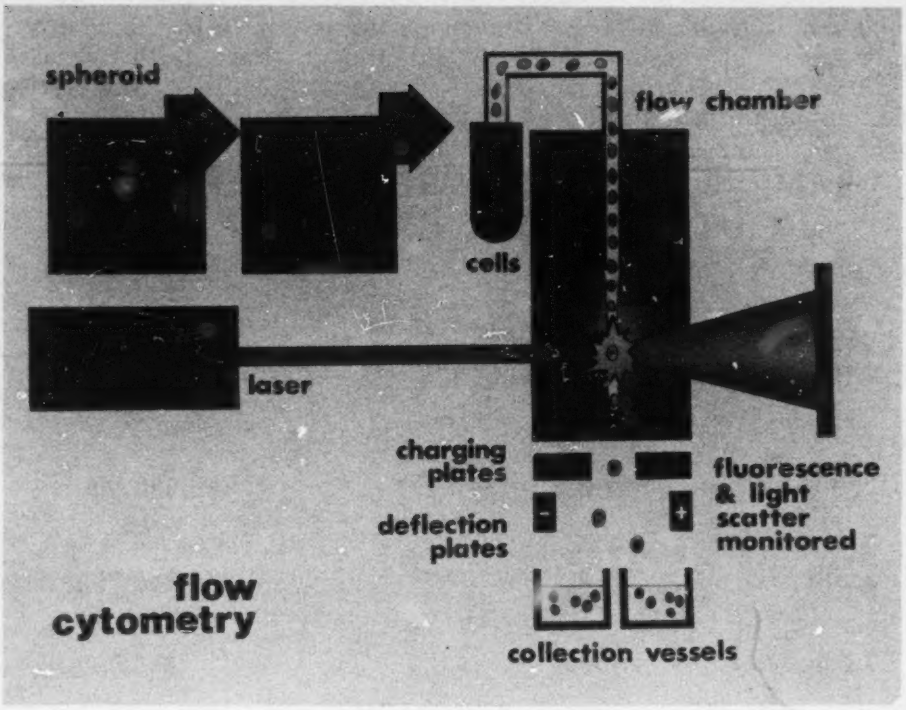


SAMPLE SIZES REQUIRED FOR LOW DOSE MUTATION EXPERIMENTS IN MICE

DOSE (MR)	PERCENT INCREASE IN MUTATION FREQUENCY	SAMPLE SIZE REQUIRED
500	0.5	11,780,000,000
5,000	5.0	124,240,000
100,000	100.0	816,000

SLIDE 10

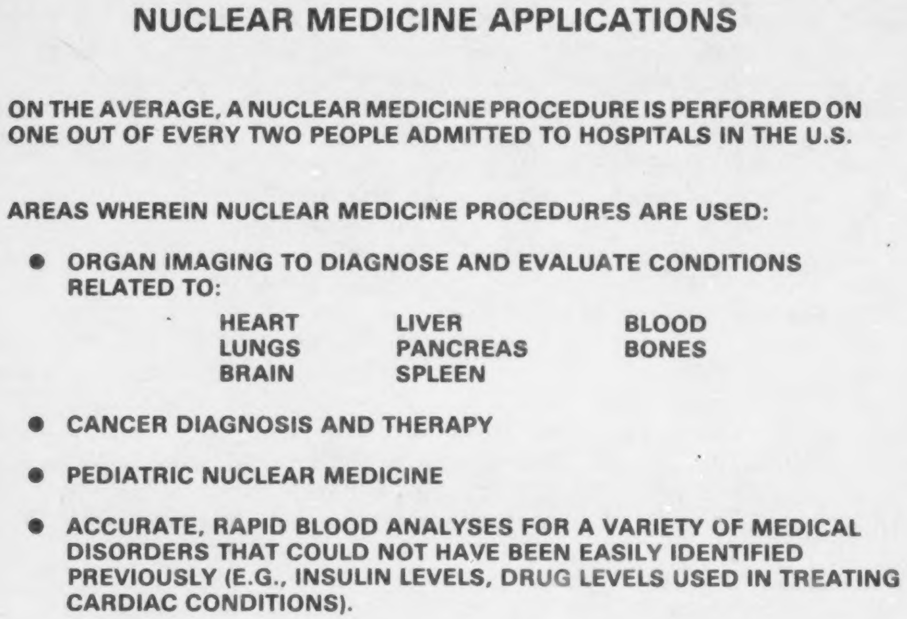
As I indicated we are very much concerned about low-level radiation effects. In order to do these studies one has to look at large numbers of organisms, either humans or experimental animals. If you wanted, in the case of radiation studies in the genetic area, to detect a 5-percent increase in mutation rate above the spontaneous rate, with current techniques that are available it would require 11.8 billion mice to do the study. If one could increase the resolution, of the genetic test that one would use by an order of magnitude, say have 70 specific geneloci that one studies, as opposed to 7 as in this case, one would reduce the number from 11.8 billion by a factor of 100. If one could reduce the sample size markedly, one might be able to do the experiment. In order to get low-level radiation, or chemical effects data, however one would have to trick the system; you would have to do it a different way.


spheroid
flow chamber
cells
laser
charging plates
deflection plates
fluorescence & light scatter monitored
flow cytometry
collection vessels

SLIDE 11

We have developed in our program—our basic research program—an instrument which is a flow cytometer. This flow cytometer can look at hundreds of thousands of cells—not people, but hundreds of thousands of cells—in just a few minutes. Therefore, one could look at a population of red or white blood cells of the order of several millions and try to detect 1 mutant cell in a million normal cells or 1 mutant cell in 500,000 normal cells. This would give you an indication of what the human mutation rate might be. These studies are being conducted. The mutant cell with monoclonal antibodies can be labeled with a fluorescent dye and if the mutant does, indeed occur, a laser beam will identify that mutant cell, quantitate it and separate it for further study.

With instrumentation of this type which is being developed in our program, we hope to be able to get quantitative information on both genetic effects and carcinogenic effects.



NUCLEAR MEDICINE APPLICATIONS

ON THE AVERAGE, A NUCLEAR MEDICINE PROCEDURE IS PERFORMED ON ONE OUT OF EVERY TWO PEOPLE ADMITTED TO HOSPITALS IN THE U.S.

AREAS WHEREIN NUCLEAR MEDICINE PROCEDURES ARE USED:

- ORGAN IMAGING TO DIAGNOSE AND EVALUATE CONDITIONS RELATED TO:

HEART	LIVER	BLOOD
LUNGS	PANCREAS	BONES
BRAIN	SPLEEN	

- CANCER DIAGNOSIS AND THERAPY
- PEDIATRIC NUCLEAR MEDICINE
- ACCURATE, RAPID BLOOD ANALYSES FOR A VARIETY OF MEDICAL DISORDERS THAT COULD NOT HAVE BEEN EASILY IDENTIFIED PREVIOUSLY (E.G., INSULIN LEVELS, DRUG LEVELS USED IN TREATING CARDIAC CONDITIONS).

SLIDE 12

I think we will skip now to nuclear medicine. As I indicated, we have a responsibility for the development of new and improved uses of radiation, radionuclides and stable isotopes for diagnosis of human disease.

This, simply, gives you an idea of what our program hopes to achieve. We are not just interested in being able to take an X-ray and seeing a bone and seeing whether or not there is a tumor there. We are really interested in the actual dynamics of what is going on in the organ or organism at the time so that we can look dynamically at the heart function, lung function, brain, liver, pancreas, et cetera. In this way, one can get some idea of what the activity of a particular individual might be and actually aid in the diagnosis of a specific disease or abnormal condition.

Mr. CARNEY. Dr. Edington, may I please stop you at that point. You are bringing out things that I am in total agreement with and I am sure the chairman is in total agreement with, but when we look at the life science and nuclear medicine budget lines, in nuclear medicine they are reduced 19 percent. Are you going to be able to continue these programs at the levels you are at?

Dr. EDINGTON. Mr. Chairman—I am sorry, Mr. Carney——

Mr. CARNEY. That is fine. I am glad you concede to the future and I appreciate it. He is going to be a fine ranking minority member, too.

[Laughter.]

Dr. EDINGTON. I think that the true reduction in nuclear medicine is less than $500,000. The number that you see in the budget submission does not include $2.5 million which is for the Bevalac operation at Berkeley. Those dollars were transferred to the nuclear physics program but they will still be used to support our research activities. The intent was to put all the operating dollars in one place so that the machines could be operated. The research dollars are the dollars that you see there. So, we start with $19 million and we go to $18.5 million. You can add on to that $2.7 million in 1982 and $2.5 million in 1983.

Mr. **Carney**. And that was in what line item?

Dr. **Edington**. That is in the nuclear medicine.

Nuclear physics in the Office of Energy Research.

Mr. **Carney**. $2.7 million was in there in 1982?

Dr. **Edington**. That is correct.

Mr. **Carney**. If I can, knowing the geography of my district, could you identify where the reductions would be then in fiscal year 1982? I must admit that I said 19 percent but that was 19 percent to the continuing resolution for fiscal year 1983. But, we do have reductions that will take place in nuclear medicine.

Dr. **Edington**. A $400,000 or $500,000 reduction. Mr. Carney, I could not tell you, at this particular moment, from where that would be taken.

Mr. **Carney**. When you have a reduction—$400,000 or $500,000 is not an enormous amount of money—could you provide for the record—I know that it is difficult if you do not have in-depth figures for the budget in front of you. Does that have any impact on ongoing programs and, more specifically, on employees that are involved in that type of thing? Will we be losing—I am not so concerned about administrative—I am talking about in the research program, are we going to be losing people who put their bellies to a desk and look into a microscope and do the research, the scientists?

Dr. **Edington**. We would not expect a reduction in personnel in nuclear medicine, but in some other cases, yes, sir.

Mr. **Carney**. We will be. Thank you.

Mr. **Scheuer**. Will that impair the integrity of these programs in the sense that you want to have an adequate knowledge base for us to act within the next year?

Dr. **Edington**. I think when one is considering the levels that we are talking about of $400,000 or $500,000, no, but at larger levels, yes it could.

Mr. **Scheuer**. Is that true for some of the other programs you have been describing?

Dr. **Edington**. I would have to say yes. There would be an impact.

Mr. **Scheuer**. It would reduce the effectiveness of this research in terms of giving us an adequate knowledge base to act legislatively by this time next year?

Dr. **Edington**. Mr Chairman, I think that the situation is one that at any given time, when budget situations are tight, one can conceivably reduce programs without destroying the efficiency or productivity of that program. I think under these circumstances, that is the situation as we see it.

Mr. **Scheuer**. You do not have any fears or reservations that the data base that you provide for us next year and the conclusions that you will be able to produce from the research that you are doing now, at the level at which you propose to fund it, would give us an inadequate data base on which we could function next year as legislators?

Dr. EDINGTON. I think I can answer that honestly, no. I do not think that it would.

Mr. SCHEUER. I would be happy to yield to my colleague.

Mr. CARNEY. I was just asking for a clarification at that point, when you were talking about giving us knowledge to move on legislation next year, I jumped the gun and we moved onto another line. I do not think we were talking about the same thing—although Dr. Edington did answer your question, I do not think it was in relation to my question.

Would you please continue.

What I am saying is that the question that the chairman had asked was not really in relation to my question. He is talking about legislation that he and I are greatly concerned with in the coming year. We are looking for a time frame that we can move on a topic that was not the same as what I was pursuing with the $500,000 level.

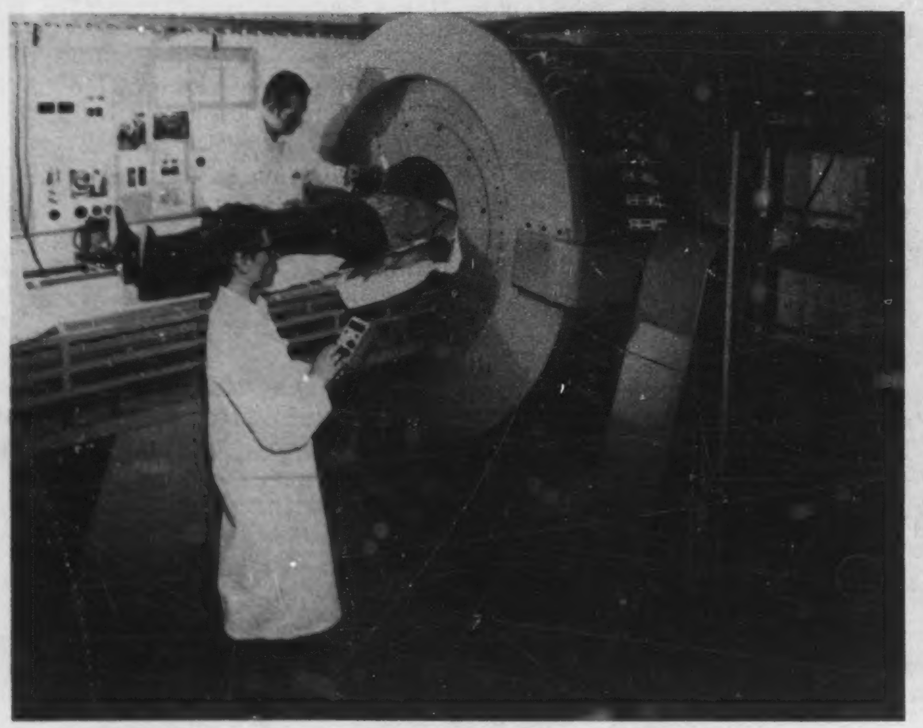
Dr. EDINGTON. I will provide that.

[Material referred to follows:]

REDUCTION IN NUCLEAR MEDICINE

Promising initiatives for the treatment of cancer using boron containing compounds and neutron irradiation will be postponed. Development of applications of stable isotopes for the diagnosis of disease and for the study of human physiology, which would allow tests presently requiring radioactive materials, have to be slowed down.

Mr. CARNEY. Thank you.



SLIDE 13

Dr. **Edington**. In this viewgraph we have a picture that has been taken with what you would call a radiation camera I suppose. It is a position emission tomograph in which one can measure the activity of specific regions of a body of an individual.

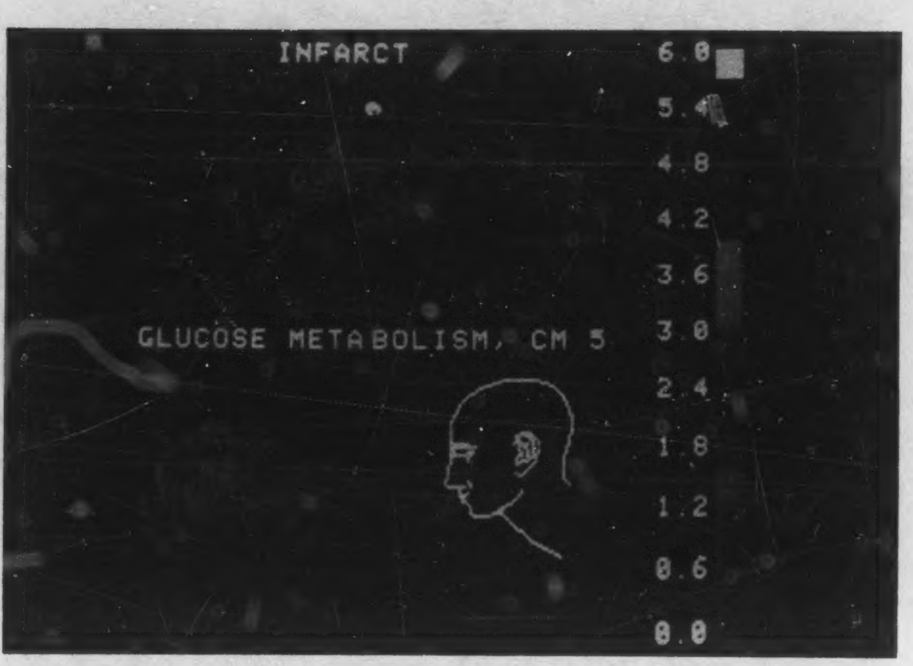
Glucose, for example, a sugar is needed by cells——

Mr. **Scheuer**. That is the CAT scanner that we have been hearing about?

Dr. **Edington**. This is the PET, the descendent of the CAT.

Mr. **Scheuer**. I see, son of cat. [Laughter.]

Dr. **Edington**. Right. Sugar is a material that cells need for energy. One can label a sugar molecule with a radionuclide, inject it into the individual and that labeled molecule will go to an active cell which is in need of sugar. Using computers one can take pictures with this machine. Using computers one can, on the next viewgraph demonstrate the activity within a human brain.

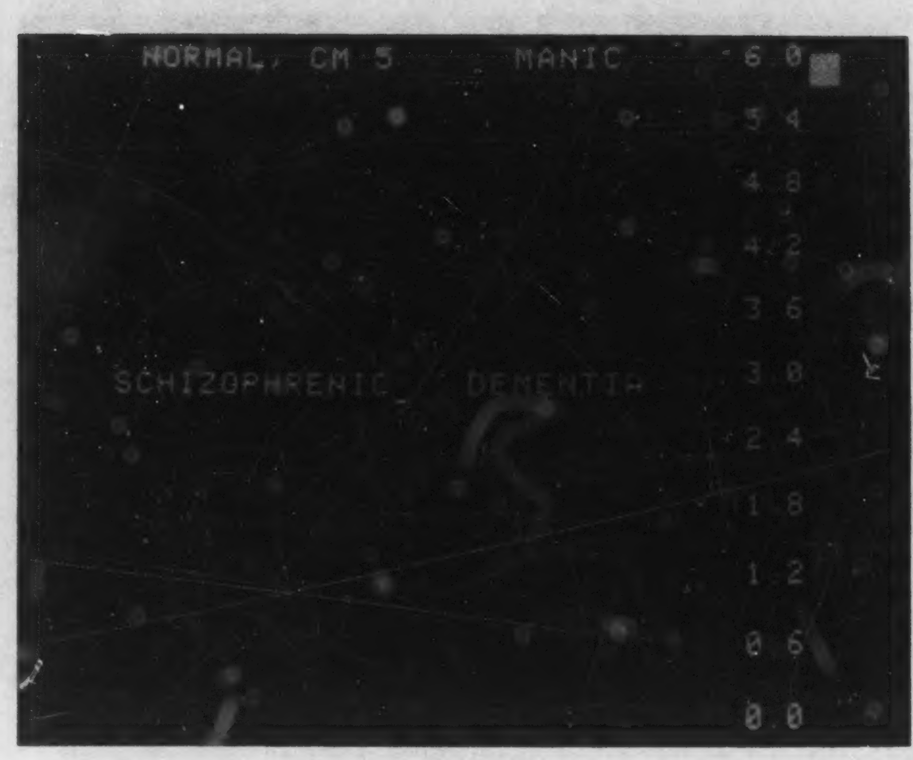


SLIDE 14

In this particular case, a cut was taken about 5 centimeters below the top of the skull and the activity is demonstrated in a normal individual on the bottom where you see yellow and orangish-red colors which are very active. Green and blue are inactive. You see at the top there has been a stroke in the lower left-hand region which has been demonstrated here because the cells in that particular area are not active, are not utilizing the sugar molecule and, as a consequence, no radiation activity is being demonstrated there.

Mr. Scheuer. This is designed to measure the patients ability to handle sugar and glucose?

Dr. Edington. That is right, the metabolic activity of that particular region of the patient, correct.



SLIDE 15

In this case we have a normal individual compared with three individuals with mental problems. In the upper right a manic individual. As you know, manic individuals are hyperactive and as you can see there is an increased utilization or metabolism of the glucose or sugar.

In the lower left-hand corner, an individual is schizopherenic and you see relatively small activity in the cells of the brain and, of course, in an individual in a dimentia situation has, essentially, no activity.

The use of these materials aid the physician in clinical medicine to actually determine what the problems are with his patient.

Mr. Chairman, that concludes my long testimony.

[The prepared statement of Dr. Edington follows:]

Statement of Charles W. Edington
Associate Director
Office of Health and Environmental Research
Office of Energy Research
Before the
Subcommittee on Natural Resources, Agriculture
Research and Environment
House Committee on Science and Technology
March 11, 1982

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to present to you the FY 1983 budget request for the Biological and Environmental Research and Life Sciences Research and Nuclear Medicine Applications programs conducted by the Office of Health and Environmental Research. These research programs were formerly an integral part of the DOE Office of Environment. In last year's reorganization of the Department, these programs were transferred to the Office of Energy Research.

These health and environmental research programs had their origin in the Division of Biology and Medicine which was created by the Atomic Energy Commission. As a result, most of the research on the biological effects of radiation supported by the Federal Government has been funded by this office. The legislation that established the Energy Research and Development Administration and later the Department of Energy broadened the mission of the Office of Health and Environmental Research to include a comprehensive research program on the environmental effects of energy technology developments.

For budgetary purposes, the research activities of OHER are divided into two major programs. They are: (1) Biological and Environmental Research; and (2) Life Sciences Research and Nuclear Medicine Applications. As shown in Table 1, the FY 1983 request for these two research programs is $168.9 million, a decrease of $43.5 million. In FY 1983, these programs are focused on the highest priority basic and generic research activities, with less emphasis on short-term process-specific research. I shall discuss these two research activities separately.

Table 1

Office of Health and Environmental Research
(BA in thousands)

	FY 1982	FY 1983
Biological and Environmental Research	$164,990	$129,845
Life Sciences Research and Nuclear Medicine Applications	47,386	39,020
Total	$212,376	$168,865
Less Carbon Dioxide Research	12,024	8,000
Total OHER	$200,352	$160,865

BIOLOGICAL AND ENVIRONMENTAL RESEARCH

The Department's Health and Environmental Research Program was established to conduct a scientifically sound and comprehensive program of research and assessment to identify, analyze, and reduce health and environmental uncertainties that impede the safe and economical implementation of domestic energy policy. To achieve this objective, we must study those agents that are believed to be toxic and determine their effects, if any, on human health and the environment. While the Federal role calls for a long-term, wide ranging research program, the industry role focuses more narrowly on activities necessary to ensure compliance with established Federal and State standards and regulations. For the most part, this industry role involves preoperational and operational monitoring for the specific criteria pollutants defined by the Environmental Protection Agency and short-term toxicological testing to ensure the safety of workers.

The Biological and Environmental Research (BER) program represents the primary long-term, multidisciplinary research effort in the Federal Government that is focused on energy-related health and environmental issues. No other Federal agency addresses the wide array of energy options, i.e., fossil, nuclear, and renewable resources, or sponsors the broad diversity of disciplinary research needed to resolve the various health and environmental issues. This breadth of undertaking is important because it permits a high degree of scientific synergism whereby broadly applicable hypotheses are developed from information gathered on a number of different energy activities. The goal of this program is to support the research required to determine the health and environmental effects of pollutants which may pose potential hazard to the public or the environment. These effects, and especially the late effects that occur years after the exposure (such as cancer, birth defects or genetic change) cannot be determined in quick, simple experiments. Rather, it requires an integrated program of research designed to identify, measure, and characterize energy-related releases; understand their transport, conversion, and environmental fate; determine their ecological impact; and define their potential effects on human health. The product of such a research program is a scientific information base which can be used to assess the potential human risks associated with exposure to energy-related pollution. In this way, it is possible to help ensure that a balance is maintained between the Nation's energy needs and the quality of human health and the environment.

The FY 1983 budget request for Biological and Environmental Research is $129.8 million, a decrease of $35.1 million below the FY 1982 budget. Of this amount $121.3 million is for operating expenses; $7.5 million is for capital equipment; and $1.0 million is for construction.

We will be supporting a number of research efforts including:

o Continued long-term human studies and experimental animal investigations on the late biological effects of exposure to low doses of ionizing radiation.

o Continued research to understand the mechanisms involved in the development of cancer and other late effects which result from exposure to energy-related toxic pollutants and physical agents such as radioactivity.

o Long-term experimental research to obtain information on the late biological effects resulting from exposure to toxic agents associated with the production and use of synthetic fuels from coal and shale.

o Short-term research on chemical characterization and biological analysis of products and wastes from synthetic fuel processes.

- Generic research on the processes involved in the transport, chemical conversion, fate and environmental effects of energy-related waste products, including those causing acid precipitation.
- Research on selected issues related to renewable energy resources and conservation options.

In order to support long term human and experimental animal research, the Health and Environmental Risk Analysis program will be terminated as a budget line item at the end of FY 1982.

To obtain the needed radiation and energy-related health and environmental information, the OHER research program is integrated across a number of different scientific disciplines and is organized along disciplinary lines. Funding by program for biological and environmental research is given in Table 2.

The success of any research program is reflected in its past productivity and accomplishments. In this context, it is important to point out that the Biological and Environmental Research program has provided most of the experimental and epidemiological data on which national and international standards for protection against ionizing radiation are based. These data have served to preclude regulatory action for unnecessarily lowering current occupational or general population exposure standards. The radiation instrumentation research program is largely responsible for the current state-of-the-art detection systems, and the radiation health protection

Table 2

BIOLOGICAL AND ENVIRONMENTAL RESEARCH
(BA in thousands)

	FY 1982	FY 1983
HUMAN HEALTH RESEARCH	$ 26,199	$ 25,800
HEALTH EFFECTS RESEARCH	46,539	37,600
ENVIRONMENTAL RESEARCH	28,676	23,100
PHYSICAL AND TECHNOLOGICAL RESEARCH	31,007	23,900
HEALTH AND ENVIRONMENTAL RISK ANALYSIS	3,983	0
SUBTOTAL OPERATING EXPENSES	$136,404	$110,400
CAPITAL EQUIPMENT	9,700	7,500
CONSTRUCTION	4,000	1,000
PROGRAM DIRECTION	2,862	2,945
TOTAL BER/OHER	$152,966	$121,845
CARBON DIOXIDE RESEARCH	12,024	8,000
TOTAL BIOLOGICAL AND ENVIRONMENTAL RESEARCH	$164,990	$129,845

research effort has produced most of the radiation measurement techniques in use today. In addition, the entire field of research involved in the study of radionuclide behavior in the environment was developed under the auspices of this program.

With the creation of ERDA, attention was focused on the health and environmental issues associated with the nonnuclear energy technologies and the various conservation options being considered important in meeting our energy needs. Within the Biological and Environmental Research program, the nonnuclear energy-related health and environmental issues were identified and an integrated, multidisciplinary research effort was implemented. High priority was placed on research that addressed issues related to fossil fuels, with emphasis on synthetic fuel processes, and on the near term needs of renewable energy resources.

The remainder of this statement deals with our activities categorized by the budget headings in Table 2. It should be recognized, however, that much of our research consists of integrated programs that cut across two or more of these budget categories.

Human Health Research

Human health research provides the data that are essential for policy decisions which have significant actual or perceived potential risk to a population. Such research can help remove impediments to energy development by supplying results that will lessen uncertainties about the occupational and public health consequences associated with the developed and emerging energy technologies. The true effect of human exposure to any physical, biological, or chemical agent can be assessed or predicted only by epidemiologic or clinical studies conducted directly on humans. Thus, there is no adequate substitute for the human health research which is the focus of this program.

Human health effects research is of two kinds: acute or short term - where doses are high and effects are seen in almost all individuals soon after exposure, and chronic or long term - where the doses are relatively low and the effects may be seen only in statistical analyses comparing large exposed populations with appropriate controls, i.e., in an epidemiological approach. Human Health Research concentrates on this latter category.

The DOE human health research program focuses on potential chronic (late-occurring) effects from exposures associated with energy development. These effects, which include cancer and genetic abnormalities, may not manifest themselves for many years after exposure to a hazardous agent. The prospective approach to studying these effects clearly involves long-term observation of a study population. On the other hand, a retrospective approach, identifying the causative agents after the fact, also requires sufficient time in order to accurately recreate exposures, trace members of the study population and determine their health status.

The current research program involves investigations of environmentally, occupationally and accidentally exposed persons with emphasis on health risks that may be associated with low-level ionizing radiation. Two important epidemiologic studies of chronic external whole-body exposures to low-level radiation are the DOE/DOE-Contractor Health and Mortality Study and the Nuclear Shipyard Workers Study. The DOE/DOE-Contractor Health and Mortality Study is examining a population of 600,000 current and former employees of DOE nuclear facilities going back to radiation workers involved in the Manhattan project during the 1940s.

Data collection and analysis primarily focuses on cause of death but some health effects of current workers are also examined. Thus far, no evidence for increased mortality from cancers of bone, bloodforming organs or lymphatic tissues has been observed among workers at early uranium processing plants. Positive correlations have been detected between external radiation exposure and cancer of the pancreas and multiple myeloma among Hanford workers with cumulative exposures greater than 15 rem. As planned, this study will continue collecting and analyzing data in FY 1983.

The Nuclear Shipyard Workers Study is examining a population of 250,000 workers at eight nuclear shipyards. Over 90 percent of these workers have cumulative lifetime exposures of less than 5 rem, and thus provide an opportunity to observe a unique well-defined population of low-level radiation exposures. This study, begun in 1979 and expected to continue into 1985, has currently collected and compiled all demographic and radiation exposure data from the eight shipyards involved. During FY 1983, the first preliminary results are expected.

Under this program, support also is provided for the world's major study of acute high level radiation dose. This biomedical research effort, at the Radiation Effects Research Foundation (RERF) in Japan, provides information on the mechanisms by which ionizing radiation produces biologic damage and provides an invaluable source of epidemiologic data. The study population, 110,000 A-bomb survivors and 58,000 first-generation offspring, are examined for evidence of direct damage to the human system and for genetic effects. This research project will continue in FY 1983 and will include a multi-agency effort to reassess Hiroshima and Nagasaki radiation doses using newly available data. Results to date from the RERF study have failed to demonstrate any significant genetic effects or growth retardation in first-generation offspring conceived after the bomb but have shown strong relationships between radiation dose and certain cancer incidence rates, mental retardation and other effects related to exposure in the womb.

Health Effects Research

Health Effects Research supports studies to determine the relationship between the dose received from toxic chemicals and physical agents associated with energy activities and the induction of cancer, mutation and damage to the body's organs and other functional systems. This research is carried out by means of controlled experiment in molecular, cellular and animal test systems.

A recent and unusual achievement has been the development of the ability to identify classes of toxic chemicals in very complex mixtures, such as those encountered in coal conversion byproducts, by the coupling of chemical analysis with short term biological screening for mutagenic and carcinogenic properties.

By the use of this approach, it has been determined that a class of organic compounds, the primary aromatic amines, which represent only a few percent of the total mass of the mixture, are responsible for over 90 percent of the total biological hazard. This finding has led to the determination of the feasibility of destroying such activity by hydrogen treatment. Such treatment, however, seems to produce some temporary toxic effects in experimental animals. The results obtained in these experiments have been of considerable use to the synthetic fuel program offices as well as to OHER in guiding long term research. Evaluation of oil shale technologies currently involves a combination of short term screening and confirmatory testing in animal systems. Preliminary results from a study on rats and hamsters exposed by inhalation to raw- and spent-shale dusts show evidence of lung damage and tumor development after heavy exposures. It has been found that sunlight will activate oil shale process waters to produce carcinogens. Work in this area will continue.

The Lovelace Inhalation Toxicology Research Institute has conducted a detailed evaluation of the short and long term toxicity of inhaled diesel particle emissions. Although the fine diesel particles are deposited and retained in the deep lung for a long time, the potentially carcinogenic hydrocarbons absorbed on them are not readily removed by lung fluids or translocated to sensitive target cells. This appears to be the reason why animals exposed to these particles have not shown any latent damage or lung cancer.

There are continuing efforts to search for new, sensitive techniques and methods to detect and measure potentially toxic effects that might result from exposure to energy-related chemical and physical agents. Such methods involve research at all levels of biological organization from the molecular to the whole organism. For example: (1) An animal test system has been developed for measurement of genetic damage resulting in specific skeletal abnormalities in the first generation. Since these genetic properties are analogous to inherited human disorders, and are controlled by a number of different genes, the method is a powerful tool for prediction of genetic risk and is being applied in OHER programs. (2) A rapid cell measurement and sorting system has been developed that can detect genetic damage in human red and white blood cells. Since the instrument can analyze 100,000 cells per minute it is now possible to screen several million cells per day and thus detect genetic damage in human beings which results from low level exposure to toxic chemicals. (3) In addition, new methods are being developed to identify abnormal proteins in human tissue, body fluids, and excreta. The human body contains an estimated 30,000 to 50,000 proteins, each of which reflects the activity of a particular gene. Thus, the separation and identification of abnormal proteins in cells, body fluids, and excreta permits the detection of a wide range of genetically determined adverse health effects in large human populations. Studies are underway to validate these methods in experimental animals and humans exposed to carcinogenic agents.

Environmental Research

The Environmental Research program in OHER provides the backbone of information required to balance energy demands while maintaining environmental quality. Basic knowledge is developed in terrestrial, freshwater and marine systems on the pathways of energy-related toxic chemicals and physical agents through the environment and foodchain, the resiliency of such systems to continued impact, and the restoration of damaged ecosystems for beneficial use. From this research, predictive models are developed to assist in decisions on alternative energy strategies. With this knowledge base, it is possible for the Department to respond immediately to environmental problems not only with research results but also with a cadre of experienced people. Examples of recent research results from this program include the following:

(1) The basic research supported at Oak Ridge National Laboratory on dynamics of fish populations in the Hudson River was an important factor in the court decision in 1981 that cooling towers would not be required at the Indian Point Power Plant. This decision should apply to other power plants as well and may save energy customers millions of dollars in construction costs.

(2) In the Arctic, information on terrain, soil, and vegetation has been used to prepare maps showing the sensitivity of different ecosystems to particular stresses. These are being utilized by federal, state, and industry personnel in the Arctic for the selection of sites for energy-related activities and for the determination of those areas that should get immediate attention after accidental releases.

With the development of energy from fossil fuels and other sources in the Nation, information developed in this program will be increasingly needed so that toxic chemicals and physical agents generated from existing and new technologies can be dealt with efficiently and in an environmentally safe manner.

Soil-leachate interaction, aquifer disruption and vegetation changes will be three categories that will be investigated in this integrated research program to determine the best means of disposal of waste materials. Also, studies in the Rocky Mountains will focus on the pathways of fluorine, molybdenum, boron, and saline minerals through the environment to determine which elements must be controlled in this energy rich region and how.

Physical and Technological Research

The first step in an investigation of health effects is to identify the agents that may produce unwanted biological responses. This program area is responsible for determining the chemical nature of materials in products, effluents, emissions and wastes that produce long term biological effects or that are toxic in the short term.

An area of recent substantial interest is the buildup of chemicals and radioactive materials in homes and other buildings as the air exchange rate with the out-of-doors is reduced due to better insulation and other conservation measures. In particular, the radioactive gas radon which comes from soils and building materials has been shown to increase markedly in some homes that are very tightly insulated. A number of homes in various parts of the country are being investigated to identify the dominant source of the radon. Through these investigations, means will be developed for keeping human exposure to radon as low as possible while ensuring the economic and fuel conservation advantages of enhanced home insulation.

This program's atmospheric science research is improving our ability to describe the transport and transformation of chemical, particulate and radioactive agents as they move from source to man. These improvements are needed in order to allow better prediction of the radiation dose to the population resulting from accidental release of radio-activity and of the concentration of chemical materials downwind of energy operations such as coal conversion, shale, or geothermal processes. For example, development of an Atmospheric Release Advisory Capability (ARAC) has been completed and the program is now operational at the Lawrence Livermore National Laboratory. In the event of an accidental release of radioactivity or chemicals, local meteorological conditions are typed into the computer and very quickly an estimate of radiation dose or chemical concentration is given. This system was employed during the Three Mile Island incident to provide advice on the proper emergency response.

Current research centers upon improving the models of atmospheric transport of pollutants over regions of complex terrain. A three year experimental study of atmospheric transport in the Geysers region of Northern California has been completed and is being used to test atmospheric models. In FY 1983, the program will shift to the Western oil shale and coal conversion development areas and will be integrated with other Federal, state, and commercial activities.

In addressing the acid rain issue, the program will continue support to the Multistate Atmospheric Power Production Pollution Study (MAP^{3}S) precipitation chemistry network in cooperation with the Environmental Protection Agency. This unique network, in place since 1976, provides the chemistry data for each individual precipitation occurrence that is required to develop and validate regional source-receptor models. Precipitation chemistry data from three major North American networks are being analyzed and interpreted to define regional and seasonal concentrations and patterns of acidic deposition in the U.S. in order to determine the relative roles of man-made and natural pollutants in the acidification of rain. A 3-station experimental dry deposition research network is planned. This will provide the first attempts to quantify the dry deposition process, one of the critical and unresolved research areas in the acid rain issue.

The Physical and Technological Research program also includes the development of improved measurement techniques, chemical and radiation detector systems and dosimetry procedures. Special emphasis is being placed on laser techniques since they offer unusual promise of great improvements in sensitivity and in selectivity for specific compounds. A laser fluorescence system was built and is now being used in coal conversion operations to detect contamination of surfaces by organic material. This is useful in the industrial hygiene programs to aid in reducing worker exposure to these materials. Another laser technique has succesfully identified specific compounds without the need for extensive previous chemical separation.

LIFE SCIENCES RESEARCH AND NUCLEAR MEDICINE APPLICATIONS

The Life Sciences Research and Nuclear Medicine Applications programs are two independent and very important research efforts. The Life Sciences effort supports fundamental biological research which serves as the underpinning for the more applied, energy-related Biological and Environmental Research program. This research effort is aimed at understanding the basic structure, function, and interrelationships of the fundamental components of living organisms which are susceptible to energy-related toxic agents. The program also supports research on the development of early indicators of biological response and for the development of automated, high-resolution instrumentation and techniques for use in biological and environmental research.

The Nuclear Medicine Applications program is the world's only research and development effort aimed at developing beneficial applications of radiation, radionuclides, and stable isotopes to improve the diagnosis and treatment of human diseases. Promising new approaches are tested for feasibility and, if successful, are transferred for use in clinical medicine. Without these nuclear medicine tests, many important noninvasive methods would not exist for diagnosing abnormalities and diseases of the heart, lung, liver, central nervous system, and other organs and tissues of the human body.

While Life Sciences Research and Nuclear Medicine Applications are budgeted separately from Biological and Environmental Research, this research is integrated by and conducted within the OHER Divisions which are responsible for health effects and physical and technological research.

The FY 1983 budget request for these research efforts is $39.0 million, a decrease of $8.4 million below the FY 1982 budget level. Of this amount, $37.3 million is for operating expenses, and $1.7 million is for capital equipment. Within the operating expenses, $18.8 million, a decrease of $7.6 million below the FY 1982 budget, is for support of basic biological research, and $18.5 million, a decrease of $0.5 million, is for nuclear medicine research and development, as detailed in Table 3.

Table 3

Life Sciences Research and Nuclear Medicine Applications
(BA in thousands)

	FY 1982	FY 1983
General Life Sciences	$ 26,400	$ 18,820
Nuclear Medicine Applications	18,986	18,500
Total Operating Expenses	$ 45,386	$ 37,320
Capital Equipment	2,000	1,700
Total	$ 47,386	$ 39,020

LIFE SCIENCES

The Life Sciences research program supports activities to identify: (1) the nature and extent of the primary molecular changes that can lead to detrimental biological effects; (2) the mechanisms involved in repair of this damage; (3) the processes involved in the transition of unrepaired changes into measureable cellular effects; (4) the mechanisms involved in transforming a normal cell into the malignant state and the production and transmission of mutant cells from parent to offspring; and (5) the changes that give rise to organ toxicity or other debilitating disease in the exposed individual. Such information provides the basis for better understanding how energy-related agents cause biological damage, which factors control recovery or repair processes, which biological responses can serve as early indicators of injury, and how new approaches for estimating human risks from experimental data may be developed.

In many cases, the detection of these biological events is difficult, if not impossible, because instrumentation or experimental techniques are not available. To increase our ability to identify and measure rare biological changes, basic research in instrumentation sciences is supported. This research has been very successful in developing new and improved high resolution, automated instrumentation and techniques for application in basic and applied biomedical and environmental research. Many biomedical instruments have been successfully commercialized. These include the zonal centrifuge (for vaccine production), the centrifugal fast analyzer (for clinical testing) and flow microfluorometry (for rapid cell separation and analysis).

To obtain the information needed for a better understanding of basic biological phenomena necessary for maintenance of life processes, research in chemical physics, biophysics, molecular and cellular biology, and genetics is emphasized and supported. Numerous accomplishments have resulted from research in this program, and the data obtained have led to conceptual advances in basic and applied biology. These accomplishments include discoveries in the basic processes by which cells are protected from genetic damage by environmental agents and the development of bone marrow transplanation into a useful clinical technique.

This program has contributed to the understanding of the structure and function of the genetic system, the nature of genetic lesions, of repair processes and the measurement of mutational events. Bacterial genetics research provided the basis for developing the universally used Ames assay for rapid screening of agents that can cause cancer and mutations. Sophisticated techniques employing two-dimensional electrophoresis, i.e., a technique to separate human proteins on the basis of electric charge, are being exploited to separate and identify the body's proteins or gene products to allow early detection of abnormal changes and disease states. High resolution chromosome analysis systems have been perfected to measure genetic damage in humans following accidental exposure to toxic agents.

Neutron diffraction measurements of the three-dimensional structure of ribosomes, a protein-nucleic acid complex that plays a central role in the production of proteins, have progressed to the point that, within a year, the distribution of proteins within the ribosome will be known, marking a major milestone in the understanding of complex, life sustaining macromolecular complexes.

Modifications at the National Synchrotron Light Source facility, dedicated to biological research, will be completed in FY 198~~2~~3 and will provide sources of monochromatic x-ray and ultraviolet radiation for advanced studies of detailed structure and function of biological material.

NUCLEAR MEDICINE APPLICATIONS

The Nuclear Medicine Applications program is comprised of that segment of the health sciences devoted to the development of radioactive tracer methodology for the study of disease and the development of diagnostic and therapeutic procedures for the improvement of the care of patients. Federal support and leadership, under the auspices of the DOE and its predecessors, have been responsible for the development of nuclear medicine as a new medical specialty in this country and in the world.

This research program benefits from this agency's basic and applied chemistry, engineering, and physics programs, and complements the NIH programs which emphasize the actual, especially clinical, study of disease processes. The major advantage derived from the continuation of the nuclear medicine program under the auspices of this office has been the opportunity for investments of this agency in facilities and personnel in the fields of basic physical research and engineering. This has allowed the conduct of productive nuclear medicine efforts and efficient technology transfer at a small cost relative to the investments which would be required in the absence of this close programmatic relationship.

The scope of the nuclear medicine program includes directed basic and applied research in the development of radionuclides, resources needed for their production, preclinical and early clinical feasibility studies, and instrumentation research. In cases where clinical feasibility is demonstrated, a rapid transfer of technology is made to the commercial sector.

While most radionuclides used in clinical medicine are now produced by industry, the medical cyclotron (86-inch cyclotron) and the stable isotope enrichment program at Oak Ridge National Laboratory continue to provide essential target material for radionuclide production and a significant quantity of radionuclides for clinical medicine. Meanwhile, research on new radionuclide production technology is being conducted at advanced facilities at the Los Alamos National Laboratory and Brookhaven National Laboratory. The ability to "label" a wide variety of organic compounds with both stable and radioactive isotopes provides an opportunity to study many vital and important processes in living systems.

A major contribution of our laboratories has been the genesis and development of almost all of the instrumentation now in use in clinical nuclear medicine. The commercial sector has taken the leading role in modifying these instruments and bringing them into widespread use in biomedical research and clinical medicine. Industry, however, has not generally been responsible for the major innovations which have received widespread application. Such innovations would involve a large, high-risk capital investment; therefore, the industry relies on the federally-supported research programs for the development of major advancements in nuclear medicine instrumentation.

More effective and efficient methods of conducting research and applying new information clinically will depend on technical improvements of instruments needed to detect both stable and radioactive tracers. Better resolution of gamma rays emitted from radioactive tracers is needed to quantify more accurately defects in internal organs (such as the extent of damage in the heart muscle resulting from a heart attack) and chemical processes within living systems. Examples of recent instrumentation developments include the adaptation of mass spectroscopy and nuclear magnetic resonance spectroscopy for stable isotope detection, which are important for molecular structure determination in biomedical research, and positron-detection tomographic scanners. The availability and use of improved instruments can lead to an advance of our knowledge of biomedical processes in living systems and enhance our ability to apply that knowledge to the prevention and treatment of disease.

Radiopharmaceutical agents labeled with short-lived radionuclides are being developed because their use results in a significant decrease in the radiation dose associated with nuclear medical diagnosis. For example, the cyclotron- and generator-produced isotopes Carbon-11, Nitrogen-13, Oxygen-15, Fluorine-18 and Rubidium-82, which have half-lives ranging from 1.5 minutes to 2 hours, provide considerable reduction in radiation dose even though the labeled pharmaceutical may be retained in the body for a longer time. The further development of the use of stable isotopes of carbon, nitrogen, and oxygen for labeling pharmaceuticals offers the potential for eliminating radiation dose entirely. The increasing use of radionuclides for diagnostic tests in clinical laboratories presents significant problems in disposal of these tracers into the environment. The possibility of replacing radionuclides with stable isotopes in these tests may provide at least equivalent diagnostic information at less population risk.

Mr. Chairman, that concludes my testimony. I will be pleased to respond to any questions which you and the Committee may wish to ask.

Mr. **Scheuer**. It was longer than we had anticipated, but I must say it was very interesting and we managed to have a few little questions interjected for which you gave us very responsive answers and we appreciate it. Your testimony was excellent.

I am going to yield to my minority colleague to take over the Chair fo about 5 minutes and I assure that he will have some questions.

Mr. **Carney** [acting chairman]. Dr. Edington, could you provide for the record more specifics on Bevalac so that we could have an understanding?

Dr. **Edington**. Yes, sir.

[Material referred to follows:]

BEVALAC

The Bevalac is a unique facility located and operated at the Lawrence Berkeley Laboratory. It is currently the only facility in the world that produces heavy particle beams that penetrate to depths needed to perform radiotherapy on human cancers deep in the abdomen or brain. This facility supports a broadly based research program which provides basic information needed for future medical applications and the understanding of fundamental mechanisms of heavy charged particle interactions in biological systems.

The health and environmental research program first provided funding support to this facility in fiscal year 1972, due to the financial constraints of the Nuclear Physics program at that time. It was agreed that support of the facility would be proportionately shared by the two programs in relation to the research conducted.

As part of the fiscal year 1983 budget process, the decision has now been made to, again, consolidate all funding support of the Bevalac facility in one program. Therefore, the Life Sciences Research and Nuclear Medicine Applications budget is reduced by $2.7 million in fiscal year 1982, for comparability purposes, and $2.5 million in fiscal year 1983, with the Nuclear Physics budget being increased by these same amounts.

Mr. **Carney**. That would be of great interest to this committee—this subcommittee—although we are not going to touch it.

The other question I have, has that money for that particular project always been in that area of the budget?

Dr. **Edington**. No, sir. A few years ago when the nuclear physics program was having problems, in keeping the Bevalac going, our office actually provided a third of the operating costs for the Bevalac in order to protect our research activities.

Last year the decision was made to put all of the funds for operation of the Bevalac in one place so it would be easier for the laboratory and headquarters to control. So, we transferred that money to the basic nuclear physics program for that purpose.

Mr. **Carney**. So on last year's budget of $19 million, the Bevalac was not in that $19 million.

Dr. **Edington**. That is right.

Mr. **Carney**. So we are dealing with apples and apples on that particular budget?

Dr. **Edington**. That is correct.

Mr. **Carney**. In essence, what we are talking about is a $21.7 million budget in fiscal year 1982 reduction as opposed to a $21 million budget in fiscal year 1983.

Dr. **Edington**. That is correct.

Mr. **Carney**. An understandable and tolerable reduction. However, in general life sciences, we are going from 26.4 to 18.8. The question that I have is what programs will be involved? Are they programs that have reached their conclusion?

Dr. Edington. In some cases that is true, Mr. Carney. In other cases we have made the decision that we should reduce our support in the cell biology area, especially research related to differentiation and development of proliferating cells, and with small reductions in our biophysics and genetic studies and in our instrumentation activities.

Mr. Carney. OK. You made that decision and I know that these are questions that almost become personal and are not personal—but if you can answer it—you have made that decision given the fact of the economy of 1982 and projected economy for 1983. If things were better and we were not faced with a deficit, would you perhaps have made that same decision in that area?

Dr. Edington. I might have made that decision in certain areas within the program but not necessarily to the degree they were made.

Mr. Carney. Are there any programs that we have zeroed in the general life science area that perhaps were not programs that have reached their conclusion and we had to just stop them? Maybe the best way I can put it is are we slowing some of the research? Are we stretching some of it out rather than cutting the research and saying that we are not going to continue in that area?

Dr. Edington. I think that we have zeroed out some projects, not programs.

Mr. Carney. Projects?

Dr. Edington. Projects. Individual tasks as opposed to programs.

Mr. Carney. OK, and would they be zeroed out because they have become conclusive as far as getting the information you were looking for or just the fact that you are dealing within a certain fiscal parameter and you have to make those decisions?

Dr. Edington. I think with the budget situation as it was we had to make some of those decisions. We would have made some of those decisions regardless.

Mr. Carney. It would have been sensible under a nonrestrictive budget atmosphere to zero some of those programs out?

Dr. Edington. That is a continual situation that occurs in our program. The average life of a project, task, might be 4 years. So, at the end of the 4-year period we terminate that activity and pick up something in an area of more concern.

Mr. Carney. Capital equipment has been reduced substantially in the life science and nuclear medicine area. Could you give us the rationale for that?

Dr. Edington. I would say that in an effort to prevent further reduction of the research activities, we felt that we could reduce the capital equipment budget in the life sciences and nuclear medicine area by $300,000. In that context we felt that we had to maintain the support for the synchotron light source activities at the Brookhaven National Laboratory where we had already provided funds to develop the first phase of the biological beam line. We have identified $700,000 for additional work on the beam line at Brookhaven so that those activities can continue.

Mr. Carney. It is $700,000 and I thank you.

Dr. Edington. $700,000.

Mr. CARNEY. OK. So, again, it is partially climate and partially the fact that you are putting preferences on ongoing programs and so you can delay the purchase of capital equipment and move on.

Dr. EDINGTON. That is right.

Mr. CARNEY. If I could, and I hope that I am directing the question to the right person, I will ask you again, Dr. Edington. I have some concern about risk analysis inasmuch as it interfaces with environmental compliance. Are we going to be able to meet our statutory requirements in environmental compliance when risk analysis has been zeroed out? Is not risk analysis doing some of the present research for environmental compliance?

Dr. EDINGTON. Our health and environmental risk analysis program was initiated originally to take a look at specific energy-related areas to determine what the health or environmental risk was for two reasons. One is that it would give us at a particular moment a capsule idea of what the potential risk associated with, let us say, a liquefaction process might be. At the same time it identified for us areas in research which we needed to consider for support.

Again, with the budgetary situation as it was, we felt that it was more important for us to support the research activities which developed the data that could be used in health and environmental risk analyses of any kind. In addition to that particular aspect, EPA initiated in fiscal year 1982, a health and environmental risk analysis program, using people in our laboratories; therefore, we would expect to obtain such information from their support in that area.

Mr. CARNEY. I am not clear as to what you meant by your last remark. Are you suggesting that people will be to used in your laboratories as subjects for risk analysis?

Dr. EDINGTON. EPA is funding individuals at the Oak Ridge National Laboratory and at the Brookhaven National Laboratory to do health risk analyses. That information will be available to us as well as to EPA and any other interested parties.

Mr. CARNEY. You are going to share the data with the EPA?

Dr. EDINGTON. That is correct, and EPA will share with us.

Mr. CARNEY. And you feel that this meeting your requirement on risk analysis?

Dr. EDINGTON. I think that is correct in the synthetic fuels area especially.

Mr. CARNEY. Let me get down to something which has nothing to do with the budget line. When we talk about synthetic fuels are we trying to identify processes that will be utilized in the future? Are we trying to narrow down various processes and do environmental research on them or do we just respond every time somebody comes up with an idea to more efficiently extract oil from shale, by proceeding with environmental research on that process?

Dr. EDINGTON. I guess you would have to say that I am sort of a parasite in this particular case. I do not build those facilities. I have to utilize an available facility in order to get representative samples that would allow me to conduct a health and environmental research program.

In this country in the synthetic fuels area, we have had relatively few pilot plants available from which we can get samples. What we have tried to do is the following.

There was the solvent refined coal pilot plant from which we were able to get representative synthetic coal liquid samples, aided by the technology programs. We are still collecting samples from the H coal pilot plant. With those samples we are trying to determine in relatively rapid tests what I have tried to demonstrate in my presentation. We are trying to determine where the biological activity is and what chemical compound or compounds are producing it. In this way we can compare effects from one process to another. In our studies we have found that regardless of the pilot plant from which we get samples, the effects are the same.

In the case of oil shale the effects are the same. Quantitatively, activity in the shale materials is less than that found in the coal liquids. In natural petroleum we find some activity but it is very small and much less than that in coal or shale liquids.

What I am trying to say is that if there is an available plant from which we can get that sample then we can do that research. If there is no plant, we have a hard time.

Mr. CARNEY. I will ask one more question. I have probably extended my time here on questioning. Dr. Edington, what percentage of your total environmental research and development program is conducted by national laboratories, colleges and universities, industry, and by, say, a not-for-profit laboratory, other than the national ones?

Dr. EDINGTON. We have approximately 50 percent of our dollars in the national laboratories. Approximately 22 percent I would guess in universities, another 22 percent approximately in specialized laboratories, some of which are on university campuses, such as UCLA, the University of California at Davis, the University of California at San Francisco, Utah, Rochester, and places of this type.

Mr. CARNEY. A special laboratory, would that be a DOE laboratory?

Dr. EDINGTON. Yes; a DOE-owned——

Mr. CARNEY. Like the radiation laboratory at Notre Dame or something like that.

Dr. EDINGTON. That is a basic energy sciences laboratory, but that is right.

Mr. CARNEY. That is what you are talking about as being a special laboratory?

Dr. EDINGTON. That is right. The University of Rochester Radiobiology Laboratory is a DOE-owned facility on the University of Rochester grounds. It is one of our specialized labs. But, about 22 percent of our total money is in that particular type of institution, the rest is in industry or other Federal agencies.

Mr. CARNEY. There is very little done in industry?

Dr. EDINGTON. That is correct.

Mr. CARNEY. Are those percentages the way you would like them?

Perhaps, maybe I should ask Dr. Trivelpiece as well, or does DOE think it would be more effective if they changed the mix? Is there any interest out of DOE to change that mix?

Dr. **Trivelpiece**. Do you mean the mix relative to universities relative to national laboratories versus industry?

Mr. **Carney**. Yes.

Dr. **Trivelpiece**. I think there is not a preconceived notion on that. The point is that these are Federal funds that should be used at the best possible location to perform the work in a satisfactory manner. I think that if universities are better at doing it than the national laboratories, they should be the recipients of the funds and vice versa. There are other ancillary conditions and considerations that come into play, when you take into account that universities train people and the like, and it is not just the simple, straight merits of the case, but that for almost all circumstances is the desiderata upon which the decisions are based.

Mr. **Carney**. Would you elaborate further by answering this. Do you think that we are appropriating the moneys to the different areas that you designate in a meaningful way and a cost-effective way now?

Maybe if I rephrase that. Do you have any concern that because of political pressures within the scientific community, political pressures from the House of Representatives, the Senate, and so forth, that you are not putting some of the research and development programs where they would be best served?

Dr. **Trivelpiece**. I certainly do not think so.

My opinion that the combination of review processes which are used to determine the quality of the work, the appropriateness of the work, the consistency with mission, and so forth, serve the system very well and that the funds are expended in an appropriate and adequate manner to meet the Nation's needs.

Mr. **Carney**. Is there any thought about a retrenchment in the facilities both on campuses that are owned by DOE and those owned by the Federal Government and in our national laboratories? Is there any consideration to retrench, not based on program but based on quantity?

Dr. **Trivelpiece**. I am not sure I know what you mean by retrenchment.

Mr. **Carney**. Well, is there any thought about cutting out any university-based, federally owned facility? Say, we just cannot afford it any more?

Dr. **Trivelpiece**. Facilities have a finite life. If you are at any instant in time going to arrange all of the facilities in some sort of descending order of overall value, then there will always be some toward the bottom. For a variety of reasons those will be terminated as other considerations and other needs are established. I think the Synchrotron light source in your own district is a good example of something that has a very high priority and there are other projects that will, somewhere along the line, undoubtedly not be funded eventually, not as a result of that directly but from an indirect sense in the establishment of overall priorities.

Mr. **Carney**. I can fully appreciate that. Maybe I did not——

Dr. **Trivelpiece**. And, there will occur a time when, perhaps, the Synchrotron light source itself is no longer at a high enough priority level, given other needs to justify its continued support.

Mr. CARNEY. Well, I would suspect that statistical data would say that I am not going to be sitting here and you are not going to be sitting there when that happens—at least I would hope.

What I was trying to say was "consolidation" is probably the best word I am looking for. Is there a movement in DOE to consolidate national laboratories?

Dr. TRIVELPIECE. If you mean by combining two national laboratories into one, then no. If you mean the process of consolidation that has taken place from the days in which there were say 100 cyclotrons around the United States, one at every university, where now there are only a few, yes, that type of consolidation will continue. It simply becomes not cost effective at some point to have several underutilized facilities when you could, in fact, have one state-of-the-art facility that serves many areas of science. I think as time has progressed it has been demonstrated that an airplane ticket is an integral part of the state-of-the-art frontier science throughout the United States and throughout the world for that matter.

Mr. CARNEY. Well, I would agree with you. I was just wondering, if there had been some thought along those lines.

Dr. TRIVELPIECE. There are no direct plans that I am aware of.

Mr. CARNEY. Thank you, Mr. Chairman. Those are all the questions that I have at this point.

Mr. SCHEUER. I would ask unanimous consent that we hold the record open since some of the other members of the subcommittee may have some additional questions to submit in writing and Congressman Carney and I may also have some.

Dr. TRIVELPIECE. Mr. Chairman. I, also, would like to add something.

Mr. SCHEUER. By all means.

Dr. TRIVELPIECE. Earlier, Dr. Edington had referred to the tracer experiments in connection with the acid rain. His answer was correct but I think there are some additional considerations that should be taken into account.

This is a sensitive international situation involving both intrastate and interstate problems as well as interboundary considerations between us and Canada.

The mere fact that a particular molecule goes from one place to another and that it can be identified with appropriate technical accuracy does not necessarily give you a clue as to whether or not, in the process of transit, the chemistry was modified in a way that can be understood at the moment. So that the mere fact that transport can be accurately determined may or may not give you the information necessary to develop mitigation strategy. I would caution you not to assume that his answer will provide the necessary and sufficient technical information to develop an accurate and adequate mitigation strategy within the very near future.

Mr. SCHEUER. Dr. Trivelpiece, when are we going to have that adequate data base?

Dr. TRIVELPIECE. It is an extremely complicated technical problem; the sources, the sinks, the chemistry processes that take place during transport. I believe that what I have seen in the way of data and what has been demonstrated to me is that although, as you have indicated, their is a body of circumstantial evidence and I think that body is pretty clear, the cause-and-effect relationships are going to be difficult to determine in a way that allows a proper mitigation strategy to be put into place. It would be inappropriate to expend substantial quantities of dollars or to create regulations that were not based on a sound understanding of the problem. I was merely trying to add a cautionary note and I do not have a good answer as to how long it is going to take to provide that kind of information that you suggest.

Mr. **Scheuer**. Well, now wait a minute. We have been hearing this for several years both from your agency and from utilities and manufacturers, and from some reputable scientists too. We want to get to the point where we can act. When do you think we are going to have a sufficiently credible body of evidence and sound research data that would permit us, responsibly, to move into a mitigation strategy, a legislative strategy? And, what kind of funding would that take? Over how many years?

Dr. **Trivelpiece**. I do not have a good answer to that question. I think it is a complicated problem and will require more time than a span of a year to come to the conclusions that are needed to develop a mitigation strategy.

Mr. **Scheuer**. Well, I would request that you give us an answer to this problem. What kind of research design would be appropriate to give us those answers, over how long a period do you want to carry on that research, and what kind of funding would it require?

Dr. **Trivelpiece**. Well, we are only one part of the program concerning acid rain in the United States. There is a multiagency task force which has been developing a multiyear plan and to the best of my knowledge that plan has not been finished nor submitted yet and when it is I think it would be possible to provide a better costing out of the elements if it would be required.

Mr. **Scheuer**. When is that plan going to be submitted?

Dr. **Trivelpiece**. I do not know when it is going to be completed.

Mr. **Carney**. I think in April, Mr. Chairman.

Mr. **Scheuer**. Well, would you report back to us when that plan is going to be forthcoming and whether it will in your opinion be adequate within a reasonable time frame to provide the knowledge base on which we could responsibly construct a mitigation strategy. This is what we have been asking for for a long time. We are not scientists here but we see an enormous need for action, not just research. We have wiped out action programs in this Clean Air Act, mostly as a result from pleas from some reputable scientists and business spokesman representing utilities and industries. They indicate that we do not have an adequate data base and that we have not established those linear relationships between investment and reducing polluting effects from a reduction of acid rain 1,000 miles away.

We really want to get to the point as quickly as possible where we can act responsibly in a cost-effective, intelligent manner. However, I must say my patience is beginning to run thin, after several years of discussion we still do not have a research design that could provide funding estimates and take us to that point. I really think that you owe us that. I hope that you will get back to us with some information about when we are going to have that research design, the agencies that are involved, what the time frame would be and the funding levels that you think would be appropriate and necessary to fund that research so that whether it is a year or a year and a half from now we would be in possession of sufficient data that we could act responsibly in a legislative format.

Is that a reasonable request?

Dr. **Trivelpiece**. It is a reasonable request, sir.

Mr. **Scheuer**. Could you give us that in a week or two?

Dr. **Trivelpiece**. That we will try to do. The first part was very reasonable. We can certainly provide the information as to when the multiyear plan will be completed as the lead agency assignments by then. The time scale in which we would have to develop the answers——

Mr. **Scheuer**. And the funding. We must know what it is going to take to fund this so that we can act.

Dr. **Trivelpiece**. Well, there is an interagency committee created by the Energy Security Act of 1980 that has the responsibility for doing this. It would not be appropriate for me to usurp their responsibility.

Mr. **Scheuer**. Does this interagency committee involve NOAA, EPA, and DOE?

Dr. **Trivelpiece**. Yes, but we are not one of the lead agencies. Also included are DOI, Department of State, Department of Agriculture, NASA, CEQ, NSF, and the Tennessee Valley Authority.

Mr. **Scheuer**. What is the lead agency.

Dr. **Trivelpiece**. You mentioned two of the three.

Dr. **Edington**. NOAA, EPA, and USDA are all three lead agencies.

Mr. **Scheuer**. Could you give us the information as to which the lead agency is, I should know it but I do not and when they are going to give us that research design? And what the funding levels will be? OK?

Dr. **Trivelpiece**. Yes, sir. The information will be provided as soon as received from the interagency committee, which is expected prior to April 30, 1982.

[The information follows:]

Federal Agencies Primarily Responsible for Research Effort on Acid Deposition Phenomena

The Acid Precipitation Act of 1980 (Title VII of P.L. 96-29) created the Interagency Task Force on Acid Precipitation (the "Task Force") to implement a comprehensive program of research on acid precipitation. The Act designated the Secretary of Agriculture, the Administrator of the Environmental Protection Agency, and the Administrator of the National Oceanic and Atmospheric Administration to be Joint Chairmen of the Task Force (and the latter individual to also serve as Director of the Research program). The Act also provided for the remaining membership of the Task Force to be comprised of: (a) One representative each from the Department of Interior, the Department of Health and Human Services, the Department of Commerce, the Department of Energy, the Department of State, the National Aeronautics and Space Administration, the Council on Environmental Quality, the National Science Foundation, and the Tennessee Valley Authority; and (b) the Director, respectively, of the Argonne National Laboratory, the Brookhaven National Laboratory, the Oak Ridge National Laboratory, and the Pacific Northwest Laboratory.

The Federal agencies primarily responsible for acid deposition research are the Environmental Protection Agency, the Departments of Agriculture, Interior and Energy, and the National Oceanic and Atmospheric Administration.

Development of a Research Plan as a Basis for Legislative Action in the Area of Acid Precipitation

The Act directed the Task Force to prepare a comprehensive, 10-year research plan, "...setting forth a coordinated program (1) to identify the causes and effects of acid precipitation and (2) to identify action to limit or ameliorate the harmful effects of acid precipitation." The Task Force was charged to present a draft of the plan to Congress within six months after the bill was signed into law. This plan, the draft National Acid Precipitation Assessment Plan (NAPAP), was produced in February 1981. The development of this document is detailed in the recently submitted "First Annual Report to the President and the Congress of the United States," January 1982 (pp. 6,7). A 60-day public comment period followed submission of the draft to Congress. The Task Force revised the plan accordingly, and then produced a final draft. It is anticipated that the final NAPAP document will be presented to the Congress around the end of April 1982.

The plan reflected in NAPAP provides a broad overview of the Nation's acid deposition research program. It delineates areas of research needs in acid precipitation, including a prioritized list of research tasks in response to legislative requirements. The Interagency Task Force recognizes the need for a more detailed planning document for managing a long-range research program. Through its Research Coordinating Council, the Interagency Task Force is now fulfilling this need through the development of an operational plan for the acid deposition research program.

The operational plan will present a scheme for prioritizing research in order to reach the following overall program goals:

- To provide objective measures of magnitude and extent of present impacts.
- To diagnose the causes of these impacts and relevant source/receptor relationships.
- To develop regional effects models capable of
  (a) simulating long-term trends, and
  (b) evaluating the relative efficiencies of control strategies.

The operational research plan will be articulated and time-phased to provide deliverable outputs at regular intervals. Annual reports to the Congress and the President will be made of important technical accomplishments and description of their policy implications. These outputs will take the form of assessments, and they are consistent and complementary with the schedule planned in the NAPAP that is soon to be submitted to Congress.

The details of this operational plan are being provided by the nine separate Task Groups constituted within the Interagency Task Force, and, with funding from DOE's Office of Energy Research, by four of DOE's multipurpose national laboratories (Argonne, Brookhaven, Oak Ridge, and Pacific Northwest). The development of the operational plan is now a major task of the Interagency Task Force. This plan should be finished by early summer.

Funding and Time Required

The Task Force's NAPAP document outlines a 10-year program of research, (from 1981 through 1990), as directed by the Acid Precipitation Act of 1980. The document identified nine distinct research areas, as well as the duration and degree of involvement of the respective agencies in each of these tasks. The more detailed operational plan now under development (discussed in the previous section) should provide a basic structure for the implementation of the research program. Although the question of the time and funding level can only be properly answered by the three Joint Chairmen of the Interagency Task Force on Acid Precipitation, we would note that the Administration's acid rain program was funded at a level of $12M in FY 1981. Showing the Administration's concern with the program, the level of funding for FY 1982 is $18.4M. Moreover, the Administration has submitted a FY 1983 budget to Congress which would further increase the funding level to $22M.

When Sufficient Information Will Be Available

Although the Department of Energy is a member of the Interagency Task Force on Acid Precipitation, the Department of Energy is neither one of the legislatively identified Cochairs nor the identified Director of Research (see earlier section). In light of this, any specific answer to this question on our part would not serve useful purposes. However, we do offer the following comments with regard to this subject.

The question as to when sufficient information can result from this research in order to permit informed and responsible legislative action in the area of acid precipitation is difficult, and there is a variety of opinions on the subject. Considering the multitude and complexity of phenomena that are involved, the DOE view is that it will take a lot of research to resolve all of the uncertainties. On the other hand, this complexity does not excuse us from assessing the significance of the current body of knowledge and estimating, within reason, the amount of effort involved in what we must yet discover before meaningful cost/benefit strategies can be devised. In making such assessments, we must bear in mind that research in the many tasks which comprise acid deposition research must be interactive, and the impact of the results therefore could be unpredictable at times.

Nevertheless, it is our opinion that the Administration's proposed program now underway will lay out ongoing research paths which if properly managed over the near term could quantify many unknowns and reduce many uncertainties. Therefore, we believe that significant questions may begin to be answered that will indicate where mitigative strategies should or should not be initiated, and also allow meaningful cost/benefit analysis to be applied. Moreover, the material program must be directed such that unknowns will be narrowed and major questions answered continuously during this period, without waiting for all results at one final end point.

Mr. **Scheuer.** Well, thank you very much. We have appreciated your testimony.

Now, we will hear from Mr. William Vaughan, Assistant Secretary of Environmental Protection, Safety and Emergency Preparedness.

Mr. Vaughan, if you could sum up the highlights of your testimony in about 10 minutes then I am sure we will have some questions for you and you might introduce your colleague for the record.

STATEMENT OF WILLIAM VAUGHAN, ASSISTANT SECRETARY, ENVIRONMENTAL PROTECTION, SAFETY AND EMERGENCY PREPAREDNESS, ACCOMPANIED BY ROBERT W. DAVIES, DEPUTY ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY AND HEALTH

Mr. **Vaughan.** I will try to sum up my testimony here.

Mr. **Scheuer.** Of course, your printed testimony will be duplicated in the record.

Mr. **Vaughan.** Thank you.

Mr. Chairman, accompanying me is Mr. Robert W. Davies, Deputy Assistant Secretary for Environment, Safety and Health.

Mr. Chairman and members of the subcommittee, the goal of the Environment, Safety and Health program at DOE is to assure that the Department complies with all current and anticipated environmental safety and health statutes, regulations and other requirements and that it conducts its operation with a high quality of performance with respect to these considerations.

This program is carried out by two major components: Safety programs and environmental programs. The safety programs' component is comprised of three offices: The Offices of Nuclear Safety; Quality Assurance; and Standards, and Operation Safety. These offices are responsible for developing both nuclear and nonnuclear safety and health policies and standards, assuring their implementation by conducting technical reviews, performing comprehensive appraisals, and by sponsoring special generic technical studies to provide guidance to the Department's technology programs and field offices. They also provide an emergency response capability for accidents involving actual or potential releases of radioactive material to the environment from the Department's nuclear facilities, or for that matter any other source, public or private, when requested to do so.

The environmental programs component consists of two offices: Environmental Analysis; and Environmental Compliance which are responsible for environmental policy development, energy-related environmental issues analyses and insuring that the Department's programs and projects fully comply with the National Environmental Policy Act and other applicable environmental requirements.

The President's fiscal year 1983 budget request for the environment, safety and health program is based upon the transfer of this program to an Energy Research and Technology Administration under the Commerce Department.

While the overall fiscal year 1983 budget request of $38.995 is reduced from the fiscal year 1982 appropriation, the principal activity of assuring safety and health at operating facilities, and environmental compliance for applicable projects, will continue. In fact, there will be an increased emphasis to improve the overall safety of departmental nuclear facilities. This emphasis will involve actions to: (1) Complete the first cycle of comprehensive appraisals at the DOE Operations Offices; (2) expand the evaluation of NRC regulatory initiatives to assure that new safety restrictions for licensed commercial facilities, where applicable, are incorporated into our own DOE safety policy; (3) to develop additional criteria for fundamental training of operators of nuclear reactors and other nuclear facilities, as well as monitor implementation of those training programs; (4) to expand the atmospheric release advisory capability to provide around-the-clock 30-minute responses for Departmental facilities; (5) Complete prototype production and testing of improved neutron dosimeters for use in Departmental facilities.

The environment, safety, and health program to date has assured that national energy policies and agency plans, programs and operations have effectively addressed and expeditiously resolved environmental and safety problems. The proposed fiscal year 1983 budget request provides the resources to continue this level of assurance.

At this point, sir, I am ready to answer your questions.

[The prepared statement of Mr. Vaughan follows:]

Testimony by William A. Vaughan to the
Subcommittee on Natural Resources, Agriculture Research and Environment
of the House Committee on Science and Technology
March 11, 1982

Introduction:

Mr. Chairman, and members of the Subcommittee, I am pleased to be here today to discuss with you the Department's Environment, Safety and Health Program. With me to assist in responding to your questions, is:

> Mr. Robert W. Davies, Deputy Assistant Secretary for Environment, Safety and Health

Organization and Missions:

The goal of the Environment, Safety and Health Program is to assure that the Department complies with all current and anticipated environment, safety, and health statutes, regulations, and requirements; and conducts its operations with a high quality of performance throughout. The Environment, Safety and Health (ES&H) program is carried out by two major components; Safety Programs and Environmental Programs.

The Safety Programs component is composed of three offices: The Offices of Nuclear Safety; Quality Assurance and Standards; and Operational Safety.

As a result of a major Departmental study on the impact of the Three Mile Island (TMI) nuclear accident, nuclear safety activities were strengthened in 1981 by several new initiatives including the establishment of an Office of Nuclear Safety. This new office, with its special focus, provides an independent overview of the Agency's nuclear operations so as to minimize risks to the safety and health of workers and the public, and to provide for adequate protection of property and equipment. This overview mission is accomplished by developing safety and health policies and standards, assuring their implementation by conducting technical reviews, performing comprehensive appraisals, and by sponsoring special generic technical studies to provide guidance to the nuclear technology programs and field offices. The sub-program also provides emergency response capability for accidents involving actual or potential releases of radioactive material to the environment from the Department's nuclear facilities, and from any other source, public or private.

The basic responsibilities of the Office of Nuclear Safety arise from the Atomic Energy Act of 1954 as amended, P.L. 83-703, which required the Department to prescribe and enforce regulations and orders to protect health and minimize damage to life and property, and exempts the Department's nuclear activities from Nuclear Regulatory Commission licensing. Further, the Department prescribes and enforces effective radiological and non-radiological occupational safety and health standards and, because of this, has not been subject to Occupational Safety and Health Administration regulation in its Government-owned, contractor-operated, nuclear facilities.

The Operational Safety Office develops environmental protection, safety, and health protection policies and standards for Departmental activities not addressed by the Office of Nuclear Safety. This program is responsible for assuring that operational safety responsibilities receive Department-level oversight and management attention. These areas include Government-owned contractor-operated facilities not subject to the Occupational Safety and Health Act; hazardous waste management; air and water pollution control; and, Department aviation operations. Also included in the sub-program is the responsibility to assure the adequacy of remedial actions undertaken by the Department to decontaminate sites and facilities contaminated by radioactive material from past nuclear operations. Covered under the remedial action responsibility are sites addressed by the Uranium Mill Tailings Radiation Control Act of 1978, and others possibly contaminated by operations of the Atomic Energy Commission or the Manhattan Engineer District. Radiological monitoring and associated work, related to former weapons tests in the Marshall Islands and at the Nevada Test Site, is also covered through this sub-program.

The Quality Assurance and Standards Office, also established as a result of the Three Mile Island study, develops and coordinates the Department's Quality Assurance, Standards, and Metrication policies, overviews the implementation of these policies, and provides assistance to Department program elements in their implementation activities.

Sections 102 and 203 of the Department of Energy Organization Act provide direction for Environmental Programs activities by requiring that the Department ".....assure incorporation of national environmental protection goals in the formulation and implementation of energy programs...." and provide for functions that include "....advising the Secretary with respect to the conformance of the Department's activities to environmental protection laws and principles...."

The Environmental Programs component consists of two subprograms: Environmental Analysis, and Environmental Compliance.

The Environmental Analysis subprogram represents the Department's interests in the Federal regulatory development process, maintains comprehensive environmental data bases to permit responsive, substantive analysis of energy-related environmental issues and conducts anticipatory analyses for early identification and scoping of emerging regulatory issues.

The Environmental Compliance subprogram provides support to assure Departmental compliance with the National Environmental Policy Act (NEPA) and associated environmental statutes and regulations. The subprogram formulates Departmental compliance policies and performs a staff-intensive service function for all Agency offices to protect the Department's programs and projects from unnecessary delays due to non-compliance with NEPA and other requirements. The subprogram analyzes the need for documentation and reviews NEPA documents to assure that standards are met.

Fiscal Year 1982 Activities:

The ES&H program, which was redirected in Fiscal Year 1981 to more strongly emphasize nuclear safety, will include the following activities in FY 82:

Safety Programs

- Complete comprehensive environmental, safety, and health (ES&H) appraisals of four of the Department's eight Operations Offices.
- Activate the Council on Nuclear Safety for exchange of nuclear safety information among the Department's operating officials and key nuclear safety personnel.
- Implement a nuclear safety training program, including criticality training, fundamentals of reactor operator training, and validation of the training process through self-evaluation.
- Support the Departmental remedial action program, by conducting timely actions to establish priorities and designate sites for the cleanup of properties contaminated with radioactive materials from past government operations; and to certify the adequacy of clean up efforts and conduct post-remedial action audits and surveys.

- o Continue medical care and radiological monitoring of the Rongelap, Utirik and Enewetak people; and complete radiation dose assessments of the remaining atolls.
- o Complete the Liquefied Natural Gas experimental test spill program.

Environmental Programs

- o Develop a NEPA compliance strategy with the Assistant Secretary for Nuclear Energy, regarding the Department's Nuclear waste repository program.
- o Assist Departmental offices in meeting NEPA and other environmental requirements, as evidenced by approximately 320 NEPA Determinations and 200 Document Reviews.
- o Conduct analyses of energy/environment impacts of environmental legislation, issues, and regulations.
- o Conduct analyses of environmental control options, especially coal or synfuel related, with respect to: wastewater treatment; fire particulate and other air emission controls; leachate control and disposal of solid waste; and joint efforts with other DOE programs on control of indoor air quality.

Fiscal Year 1983 Request

The Fiscal Year 1983 request for the Environment Safety and Health Program is shown in the tabular material below, as is the appropriations for Fiscal Year 1982.

	FY 1982 Appropriation	FY 1983 Appropriation
Operating Expenses		
Safety Programs	$32,381	$28,645
Environmental Programs	13,250	3,500
Subtotal	45,631	32,145
Program direction	7,895	5,350
Total Operating Expenses	53,526	37,495
Capital Equipment	4,000	1,500
Total Environmental Safety & Health	$57,526	$38,995
Staffing	153(2)*	90(5)*

* Parentheses indicate other than full-time employees.

The President's FY 1983 Budget request for the Environment, Safety and Health Program is based on the transfer of this Program to an Energy Research and Technology Administration under the Commerce Department. While the overall FY 1983 budget request of $38.995 million is reduced from the FY 1982 appropriation, the principal activity of assuring safety and health at operating facilities, and environmental compliance for applicable projects, will continue. In fact, there will be an increased emphasis to improve the overall safety of Departmental nuclear facilities. This emphasis will involve actions to:

- Complete the first cycle of comprehensive appraisals at the DOE Operations Offices.
- Expand the evaluation of NRC regulatory initiatives to assure that new safety restrictions for licensed commercial facilities, where applicable, are incorporated into DOE safety policy.
- Develop additional criteria for fundamental training of operators of nuclear reactors and other nuclear facilities, and to monitor implementation of training programs.

Mr. **Scheuer**. Congressman Carney?

Mr. **Carney**. Thank you very much for your testimony.

In environmental safety and health, overall there has been a decrease in the total budget from $49.5 million to just a little over $33.5 million. There are certain areas of the budget that have enjoyed enormous increases; nuclear safety, quality assurance and standards. What concerns me is that the other areas have taken rather large cuts, particularly environmental analysis and environmental compliance.

Now you were in the audience, Mr. Vaughan, when I questioned the different relation between risk analysis and your environmental compliance. I would like you to address that question as well please.

Mr. **Vaughan**. I believe, Congressman, that we have the resources to do adequate risk analysis to support our operation. The environmental and health risk analysis and the environmental safety and health activity of the Department of Energy is being focused to a direct support role of our own activities. The basic research function of the environment program has been transferred to Dr. Trivelpiece's Office of Energy Research. This has been done throughout the Department so that we have consolidated the basic research function into one office. I believe we will get greater efficiencies from that activity and not lose the capability to provide the needed scientific information.

Mr. **Carney**. Well, we transferred it into Dr. Trivelpiece's baliwick and Dr. Trivelpiece zeroed out the item and you say that you think there will be adequate resources. That is a little bit of a shell game.

Mr. **Vaughan**. If I recall Dr. Trivelpiece's testimony, I believe that he said risk analysis was also being performed by EPA. If this is not your question, I would like you to state the question to me because I do not recall it.

Mr. **Carney**. My concern was that when you deal with environmental compliance you have a 50-percent reduction in that budget item? Going from $3 million to $1.5 million from fiscal year 1982 to fiscal year 1983. Compliance must have, to my knowledge, some idea of risk assessment, risk analysis, in order to comply.

Mr. **Vaughan**. We performed, Congressman, a risk analysis, sufficient to produce and review the drafts of environmental impact statements.

Let my point out, as you know, the Department has rather vast number of operating units. It is their responsibility to meet environmental safety and health requirements. At the Central Office level here in Washington, our basic role is to insure that the field operations, the program offices, the labs, are in fact complying. We are acting in effect then as the environment, safety and health overseer.

Mr. **Carney**. Within the Department?

Mr. **Vaughan**. Yes, sir, within the Department. We do not do the actual environmental compliance work. The operators do that work. It is very similar to the role that EPA has with respect to industry. EPA is the policeman; industry is the complier. In our case the field operations are the complier; we insure they are complying in operational and nuclear safety and health.

Mr. **Scheuer**. How would you characterize the level of their compliance?

Mr. **Vaughan**. To my knowledge, Congressman, DOE facilities are generally exemplary in compliance with occupational health and safety and environmental requirements.

Mr. **Scheuer**. Now, Congressman Carney just identified a drop from $3 million to $1.5 million between fiscal year 1982 appropriations and the administration's request for this year—just for environmental compliance. Your entire budget for environment, safety and health, including nuclear safety, quality assurance and standards, operational safety, environmental analysis or environmental compliance which we have discussed, and capital equipment your request is down from fiscal year 1982's appropriation level of $49 million, to your fiscal year 1983 request of $33 million. That is also a very substantial reduction of about one-third in your total budget. If you add on another 10 percent accounting for erosion of those funds, due to inflation, you are well over a 40-percent reduction in real dollars in funding; do you still feel you can adequately fund all of this work? Was it so overbudgeted before that you can afford to cut your funding by over 40 percent and still do an adequate job?

Mr. **Vaughan**. In my judgment, Congressman, yes, sir. Particularly, in view of the fact that the Department's activities generally are down. Remember I said we are the overseer of those activities. When those basic activities, operations are reduced, then the need of the overseer role is reduced.

There were many activities that were, in our judgment, dispensable or could be transferred to the private sector that did not specifically relate to the Department's compliance. Many publications and that sort of thing have been eliminated or significantly scaled down.

Mr. **Scheuer**. Which were the functions that were transferred to the private sector?

Mr. **Vaughan**. An example that we are transferring now to the private sector, or curtailing entirely, is the liquid gaseous fuels safety test. The justification for that is that under the previous administration and their approach to energy policy, they were very much encouraging the use of LNG gas. This administration is not determining what the fuel mix is. It is allowing the market to do that and sees, then, the market proponent having the duty of meeting the safety standards rather than the Government meeting it for him.

Mr. **Carney**. Well, I agree with having that take place, but as you said, you have to have an overseer or a policeman and you are the policeman. Someone has to make sure that they are in compliance.

Mr. **Vaughan**. Let me make that very clear, Congressman. I am the overseer or policeman of the Department's environment, safety, and health activities and the Department's contractors activities; I am not the policeman for the private sector. That is the Nuclear Regulatory Commission, the EPA and OSHA.

Mr. **Carney**. OK. My next question is, would you say that the majority of the cuts in your budget would be the cost of manpower?

Mr. VAUGHAN. Most of it, Congressman, is contractors, rather than direct DOE personnel. There are DOE personnel cuts but the bulk of the money is in contractor funding.

Mr. CARNEY. They are the on-site contractors. They are the eyes and ears of your——

Mr. VAUGHAN. Not necessarily. We have not been cutting the operational safety activities of the on-site contractors. That direct support-type function is still funded at essentially the same level relative to the operations. However, the things that provided information, publications and that sort of thing have either been transferred to energy research or zeroed out.

Mr. CARNEY. You talked about a reduction in the role of DOE which, then, in effect would have a reduction in your responsibilities and understandably so. However, nuclear safety has increased, let us say for argument's sake, 45 percent. Where do you see that type of activity increasing within DOE?

Mr. VAUGHAN. Where it would increase for my group, and I assume that is the thrust of your question, would be in the nuclear safety area, and there is an increase there. We have established an Office of Quality Assurance. There is a refocusing, then, in monitoring our nuclear activities. This was prompted by the Three Mile Island incident in part and the Department on its own immediately looking at its own activities and trying to determine whether a greater level of safety margin was required and reached the conclusion that it was. And, so it reorganized its safety and environmental functions.

Mr. CARNEY. Do you feel that the request that you made for capital equipment, a reduction of about 60 percent, is adequate?

Mr. VAUGHAN. Yes, I do, Congressman. I believe we have the equipment to do the functions that we think are necessary to do.

Mr. CARNEY. Well, you have added on a large responsibility in nuclear safety. Indeed, you have cut back in other areas. Do you need any special equipment for your nuclear safety program?

Mr. VAUGHAN. Let me ask Bob Davies to take that in detail, Congressman.

Mr. DAVIES. I would like to comment that the major difference between the 1982 and 1983 budgets were involved in the purchase of a helicopter for the aerial monitoring system in 1982. For remainder of the equipment, the primary costs are associated with radiation monitoring equipment for use in the aerial monitoring system and ground support systems.

Mr. CARNEY. That is fiscal year 1982?

Mr. DAVIES. That is right. Both fiscal years 1982 and 1983.

Mr. CARNEY. So what you are saying is that you go for $4 million and much of that was a helicopter last year.

Mr. DAVIES. That is right.

Mr. CARNEY. That is understandable. Now you are down to $1.5 million. Last year you would have been $1.5 million but you did not make that switch into nuclear safety as you did this year.

Mr. DAVIES. That is right. There is not a lot of capital equipment involved in the move to nuclear safety as it stands. The radiation monitoring equipment supports the nuclear safety effort which was going on before and which is continuing.

Mr. CARNEY. That was in fiscal year 1982?

Mr. **Davies**. And fiscal year 1983.

Mr. **Carney**. And 1983?

Mr. **Davies**. Yes, sir. Both the major components of those two capital budgets are radiation monitoring equipment of various types.

Mr. **Carney**. Mr. Chairman, that is all the questioning I have for the witnesses.

Mr. **Scheuer**. All right. We thank you very much for your testimony, Mr. Vaughan and we may very well have some additional questions that we will submit to you in writing.

Thank you very much for your patience and your fine testimony.

This subcommittee is ordered adjourned.

[Whereupon the subcommittee adjourned at 3:53 p.m.]

APPENDIX

Additional Material Submitted for the Record

STATEMENT OF
DR. ROGER O. McCLELLAN
BEFORE THE
SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURAL RESEARCH AND ENVIRONMENT
COMMITTEE ON SCIENCE AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES
March 10, 1982

Good afternoon, Mr. Chairman and members of the subcommittee.

I am Roger O. McClellan. I am a toxicologist and research manager whose primary interests are in the conduct of research that will provide an improved basis for estimating the potential health impacts to man from environmental or occupational exposure to various pollutants. For over 20 years, I have studied the effects of internally-deposited radionuclides with special reference to the nuclear power industry. During the past 10 years, my interests have broadened to include concern for a wide range of materials released from different energy technologies. Currently, I serve as President and Director of the Inhalation Toxicology Research Institute in Albuquerque, New Mexico. A more detailed personal resume is attached as Appendix A.

By way of background, the Institute has a multidisciplinary staff of 75 professional and 150 supporting personnel and is operated for the U. S. Department of Energy by the Lovelace Biomedical and Environmental Research Institute, a non-profit corporation. An extensive research program focusing on the toxicity of airborne materials, especially those released from energy generating or use activities, is conducted for the U. S. government in government-owned and equipped facilities. The program is a balance of basic and applied and short- and long-term research.

I am appearing today at your request to discuss the Department of Energy's Health and Environmental Research program. The following remarks which reflect my own personal opinion are based on:

1. My experience as a scientist and research manager;

2. My knowledge of the research being conducted by many of the national laboratories, specialized government laboratories, private industry and universities.

3. My service on a number of advisory groups of government agencies and the National Academy of Science; and

4. A detailed review of the budget of the Department of Energy's Office of Health and Environmental Research, the "Budget of the United States Government - Fiscal Year 1983" and supporting budget documents.

An appropriate starting point for considering the Department of Energy's Health and Environmental Research budget is provided by a quote from the President's budget message of February 8, 1982 -

> "Our goal was and remains economic recovery - the return of non-inflationary and sustained prosperity. We seek a larger economic pie to provide all Americans more jobs, more after-tax income, and a better life."

Stated succinctly, we desire a stronger economy and a better life. In my opinion, both of these are influenced to a large degree by the research carried out in the program under consideration today.

On the one hand there is wide agreement that a stronger economy must be based on new technology, capital investment and the availability of energy. A steady supply of energy in the future is best assured by utilizing a diverse range of energy technologies.

On the other hand, I presume that a "better life" includes provision of an environment that does not pose unreasonable risks to my health or that of my fellow man at home, at work or at play. Further, I assume that good health includes not only freedom from overt disease, but a pleasant environment that I enjoy seeing, smelling, tasting and touching.

Thus, society is asking for the benefits of using energy and technology while at the same time asking that their use not result in unreasonable health and environmental risks. To me, this goes to the heart of the Department of Energy Health and Environmental Research program - aiding in provision of an uninterrupted supply of energy without unacceptable health and environmental risks.

How is this utopian goal to be achieved? In my view, it is achieved by obtaining a broad base of knowledge and then using that knowledge wisely to make decisions concerning the use of various energy options. Both are essential – knowledge and wise decision making.

I am concerned that the Administration's proposed budget for health and environmental research will not allow us as a nation to develop the base of information needed for making wise decisions in the future. The two principal programs concerned with the health and environmental impacts of energy, those of the Department of Energy and the Environmental Protection Agency have been reduced by 20% or more from 1982. When the impact of inflation is considered, both programs will have been reduced by 30% or more from FY-1981. I submit that these reductions have been made largely in keeping with a desire as stated in the President's budget message "to shackle the regulatory juggernaut that burdened production, consumed jobs and diminished productivity growth." I strongly support this laudable objective. However, it will not be achieved over the long term by developing less knowledge.

In the absence of knowledge, we have ignorance. Decisions to regulate or not regulate or to promote or not promote a given energy option made in ignorance by administrative fiat have a high probability of not standing the test of time. Reversal at a later time for environmental or economic reasons or because of growing uncertainty will be expensive. One need only consider recent debates over acid rain, formaldehyde carcinogenicity, plutonium carcinogenicity or the health effects of diesel exhaust to appreciate how inadequate knowledge can create chaos and economic hardship.

I am not suggesting that I or others have a perfect vision of the future and potential environmental issues that must be addressed now to avoid future problems. However, I do think that collectively we have sufficient vision that we can carry out a highly cost-effective research program.

Let me illustrate with one example; the question of the health effects of diesel exhaust. In 1977, the automotive industry was making plans to increase their production of diesel-powered vehicles substantially. In that year the Environmental Protection Agency, using the Ames bacterial mutagenicity assay[1], demonstrated that organic extracts of diesel exhaust soot particles were effective mutagens. This raised concern over the potential for inhaled diesel exhaust inducing lung cancer. During the ensuing four plus years, a polarized argument was waged over the health effects of diesel exhaust. The automotive industry was on one side and Environmental Protection Agency on the other; a classic confrontation between the promoter and the regulator. While the argument waged and in the face of uncertainty, the automotive industry moved forward slowly with its plans to market increased numbers of diesel vehicles.

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[1] The Ames bacterial mutagenicity assay was developed by Dr. Bruce Ames and associates at the University of California-Berkeley with support from the U. S. Department of Energy and its predecessor organizations.

At the height of uncertainty over the health effects of diesel exhaust, our Institute, in early 1979, was asked by the Department of Energy to undertake a research program that would assist in resolving the uncertainty. The Department of Energy's interest stemmed from recognition of the fuel economy of diesel vehicles giving rise to the potential for a favorable impact on national petroleum needs. The program we initiated was not a traditional toxicity testing program designed to give a yes or no regulatory-oriented answer. It was a research program[2] directed at understanding (a) the physical and chemical nature of diesel exhaust, (b) its movement to the breathing zone of people, (c) its deposition and fate in the body when inhaled and, ultimately, (d) the way in which disease was produced, if it was produced.

As a result of this research, and complementary work done by Environmental Protection Agency, industry and others, we have learned a great deal about diesel exhaust and its potential for producing ill health. The research has extended from work with pure chemicals in simple "test tube" systems to cells and tissues and to animals exposed to varying levels of diesel exhaust. As a result of this integrated, multidisciplinary approach, we have begun to better understand how the positive results of the original mutagenicity assays of diesel exhaust extracts in bacteria can be reconciled with our failure to date to demonstrate lung cancer induction in animals and people exposed to diesel exhaust. All of the answers are not in at the present time but we can say with some confidence that it is not likely that increased use of diesel vehicles will cause an epidemic of cancer. This is re-assuring; it has an obvious impact on the decision to regulate or not regulate diesel emissions and if regulated how they will be regulated. Equally as important, it has clear implications for our national economy as impacted by the "health" of the automotive industry and our national needs for petroleum. In short, the picture today is clearer because research was conducted to acquire new and relevant knowledge.

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[2] The research program developed to evaluate the potential health effects of diesel exhaust is typical of the broad orientation of much of the Department of Energy's Health and Environmental Research program. Some summary "Comments on Direction of Energy-Related Health Research" are attached as Appendix B.

Please do not misinterpret what I have said. I am not suggesting that the results of our Institute's research alone has instantly changed the diesel picture. What I mean to convey is that research from a government-supported institution known for the quality of its work and its independence has had major impact on a question of vital national interest. The relative cost of the program has been small; there is potential for the costs being recovered in a short period of time by the favorable economic impact of reduced demand for foreign oil. In the same vein, it is tempting to speculate on what the impact might have been on our ailing auto industry if our present level of knowledge would have been obtained 3 or 4 years earlier. It could not have done anything but help.

The message is clear; it is necessary to look beyond today's problems and anticipate what tomorrow may bring. It is my opinion that this is being done in the Department of Energy's Health and Environmental Research program which addresses a number of different energy technologies. Unfortunately, this forward looking program will be severely crippled if the budget cuts proposed in the Administration's budget are enacted. The proposed budget for FY-1983 represents a reduction of more than $40 million from FY-1981. This translates into the loss of over 1000 scientists and supporting personnel from our national program dedicated to understanding the impacts of energy technologies on man and the environment. I can assure you that the people to be terminated are not paper shuffling bureaucrats writing regulations. These are valuable members of research teams that have taken years to develop.

The result of these reductions is likely to be increased emphasis on (1) the short term at the expense of the long term, (2) the use of "sure cinch" approaches at the expense of innovation, and (3) the investigation of the current problem, i.e. acid rain at the expense of concern for the next decade's problems. In my opinion, the proposed funding reductions are shortsighted. They increase the potential for future health and environmental calamities and economic hardship. The alternative path appears clear — make modest investments in research today that will provide knowledge that will allow wise decisions to be made in the future on how best to meet our nation's energy need while avoiding unreasonable risks to health and environment.

APPENDIX A

RESUME

McCLELLAN, ROGER O.

President and Director, Inhalation Toxicology Research Institute, Lovelace Biomedical and Environmental Research Institute, P. O. Box 5890, Albuquerque, New Mexico 87185

Date of Birth:	January 5, 1937
Place of Birth:	Tracy, Minnesota
Married:	June 23, 1962 to the former Kathleen Mary Dunagan
Children:	Eric John 7-17-65; Elizabeth Christine 7-24-67; Katherine Ruth 4-9-70
Soc. Sec. #:	539-32-6724

EDUCATION:

Doctor of Veterinary Medicine with Highest Honors. Washington State University Pullman, Washington, 1960

Master of Management, Robert O. Anderson Graduate School of Management, University of New Mexico, Albuquerque, NM, 1980

PROFESSIONAL LICENSURE AND CERTIFICATION (by examination):

Veterinary Medicine, State of Washington, 1960

American Board of Veterinary Toxicology, Diplomate, 1967

American Board of Toxicology, Certificate, General Toxicology, 1980

EXPERIENCE:

1976 - present	President and Director, Inhalation Toxicology Research Institute, Lovelace Biomedical and Environmental Research Institute, Albuquerque, New Mexico
1973 - 1976	Vice President and Director of Research Administration and Director, Inhalation Toxicology Research Institute, Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico
1966 - 1973	Assistant Director of Research and Director, Fission Product Inhalation Program, Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico
1965 - 1966	Scientist, Medical Research Branch, Division of Biology and Medicine, U. S. Atomic Energy Commission, Washington, D.C.
1965	Senior Scientist, Biology Department, Pacific Northwest Laboratories, Battelle Memorial Institute, Richland, Washington (leave of absence to the U. S. Atomic Energy Commission)
1963 - 1964	Senior Scientist, Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington
1959 - 1962	Biological Scientist, Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington
1957 - 1958	(Summers) - Junior Scientist, Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington
1957 - 1960	Research Assistant, Department of Veterinary Microbiology, Washington State University, Pullman, Washington

ACADEMIC AFFILIATIONS:

1970 - present	Adjunct Professor, Department of Radiation Sciences, School of Pharmacy, University of Arkansas Medical School, Little Rock, AR
1971 - present	Clinical Associate, Department of Pathology, The University of New Mexico School of Medicine, Albuquerque, New Mexico
1973 - present	Adjunct Professor, Department of Biology, The University of New Mexico, Albuquerque, New Mexico
1980 - present	Adjunct Professor, Department of Veterinary and Comparative Anatomy, Pharmacology and Physiology and member, Graduate Faculty of the Program in Veterinary Science, College of Veterinary Medicine, Washington State University

APPOINTMENTS

1967 - 1973	Member — Joint Space Nuclear Systems/Biomedical and Environmental Research Working Group
1968 - 1970	Advisor — Laboratory Animal Biology and Medicine Training Program, University of California-Davis
1968 - 1971	Consultant — National Institute of Environmental Health Sciences, National Institutes of Health
1969 - 1973	Member — Toxicology Study Section, National Institutes of Health
1970 - 1975	Member — Subcommittee on Whole Animal Radiobiology & Pathology - Los Alamos Meson Physics Facility (LAMPF)
1973 - 1976	Member — Advisory Board on Veterinary Specialties, AVMA
1975 - 1976	Member — Biomedical Advisory Committee on Health Effects for Reactor Safety Study to the Nuclear Regulatory Commission
1971 - present	Member — National Council on Radiation Protection and Measurements (Program Committee, Member, 1977-present, Chairman, 1980-present)
1969 - 1979	Chairman — Scientific Committee #30 of National Council on Radiation Protection and Measurements
1977 - present	Member — Scientific Committee #57 of National Council on Radiation Protection and Measurements
1976 - 1977	Member — Ad Hoc Committee on 'Internal Emitters', National Council on Radiation Protection and Measurements
1972 - 1980	Member — Transuranium Technical Group (Advisory to U. S. Department of Energy)
1972 - 1977	Member — Environmental Radiation Exposure Advisory Committee of the U. S. Environmental Protection Agency (Chairman 1974 - 1977)
1974 - 1980 1982 - present	Member — Executive Committee, Science Advisory Board, U. S. Environmental Protection Agency
1977 - 1978	Chairman — Ad Hoc Review Committee on Scientific Criteria for Environmental Lead, Science Advisory Board, U. S. Environmental Protection Agency
1978 - 1980	Chairman — Ad Hoc Review Committee on U. S. Environmental Protection Agency 5-Year Research Plan, Science Advisory Board
1978 - 1979	Co-Chairman — Ad Hoc Committee on U. S. Environmental Protection Agency Health Effects Research Program
1974 - 1978	Member — National Institutes of Health, Animal Resources Advisory Committee

1974 - present	Member — North American Late Effects Group Steering Committee
1976 - 1980	Associate Editor — Laboratory Animal Science
1974 - 1976	Member — Ad Hoc Committee - "Hot Particles" - Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR) — National Research Council/National Academy of Science
1977 - 1980	Member — Committee on Animal Models for Research on Aging, Institute of Laboratory Animal Resources, National Research Council/National Academy of Science
1977 - 1980	Chairman — Subcommittee on Carnivores, Committee on Animal Models for Research on Aging, Institute of Laboratory Animal Resources, National Research Council/National Academy of Science
1977 - 1980	Member — Enewetak Atoll Cleanup Advisory Group (Advisory to U.S. Department of Energy)
1978	Chairman — Health Effects Panel, Environmental Impact of Oil Shale Technology Workshop (EPA, DOE, HEW sponsored)
1979 - present	Member — National Academy of Science/National Research Council, Committee on Toxicology, Chairman, 1980 - present
1980 - present	Ad Hoc Member — Board on Toxicology and Environmental Health Hazards, National Research Council/National Academy of Science
1980 - present	Member — Environmental Health Committee, Science Advisory Board, U. S. Environmental Protection Agency (Chairman, 1982 - present)
1980 - present	Member — Ad Hoc Clean Air Scientific Advisory Committee on Health Effects of Sulfur Oxide and Particulate Matter, U. S. Environmental Protection Agency
1980 - present	Member — Editorial Board, Journal of Toxicology and Environmental Health
1980 -	Member — DOE Dose Assessment Advisory Group
1981 -	Member — Health Research Committee, The Health Effects Institute

PROFESSIONAL AFFILIATIONS AND HONORARIES:

Health Physics Society (Program Committee 1970-1973 and Chairman - 1972)
Elda E. Anderson Award - Health Physics Society (1974)
Radiation Research Society (Finance Committee Chairman, 1979 - present)
American Association for the Advancement of Science (Fellow)
American Board of Veterinary Toxicology (Diplomate 1967; President 1970-1973)
American Board of Toxicology (Certification - General Toxicology, 1980)
American College of Veterinary Toxicologists (Councilman 1968-1971)
American Veterinary Medical Association
New Mexico Veterinary Medical Association
New Mexico Zoological Society (Board of Directors - 1970-1972)
Washington State Veterinary Medical Association
Society for Experimental Biology and Medicine
Society of Toxicology (Committee on Legislative Assistance, 1978-1980; (Program Committee, 1980-1983)
Sigma Xi
Phi Kappa Phi
Phi Zeta
Alpha Psi

GUEST LECTURER:

University of Washington
Washington State University
Oregon State University
University of California-Davis
Ohio State University
University of New Mexico
University of Kansas
West Virginia University

AREAS OF INTEREST

Dr. Roger O. McClellan's research interests are centered in two broad areas; (1) inhalation toxicology, and (2) late effects of internally-deposited radionuclides. He is particularly interested in the conduct of animal experimentation to develop information that may be used to predict the consequences of accidental exposure of man or establish standards to assure the safe and orderly conduct of activities that may result in release of toxic agents to man's environment. His recent research has been concerned with airborne materials associated with a wide range of energy technologies including nuclear power, coal combustion and gasification, and use of diesel-powered vehicles. In each area his research has spanned from the conduct of animal toxicity studies to the development of quantitative assessments of the risk to man.

In addition to his direct research interests, Dr. McClellan has had a continuing interest in organizational management, especially the management of research. His activity in this area has centered on the management of a multidisciplinary team of professionals, technicians and support personnel to address complex problems including the use of a matrix management approach.

PUBLICATIONS AND PRESENTATIONS:

Dr. McClellan is author or co-author of over 200 scientific publications, abstracts and document reports and has given numerous presentations before scientific and lay audiences.

June 17, 1981

APPENDIX B

COMMENTS ON DIRECTION OF ENERGY-RELATED HEALTH RESEARCH

Roger O. McClellan, D.V.M.
Lovelace Inhalation Toxicology Research Institute
Albuquerque, NM 87185

In my view the overall objective of the health-related research of the Department of Energy should be to provide an information base that will allow development and deployment of energy technologies in a manner that will minimize health costs relative to the overall benefits received by society. This requires the conduct of research that is based on substantial knowledge of current and developing energy technologies so that it can have a high degree of relevance. It should be a program that specifically focuses on health issues related to energy and complements health research supported by other agencies. The DOE is the only agency that is concerned with the impacts of the total energy cycle. It goes without saying that the research must be of high quality and conducted with scientific independence so that information obtained will be viewed with confidence by other scientists, other parts of DOE and society at large.

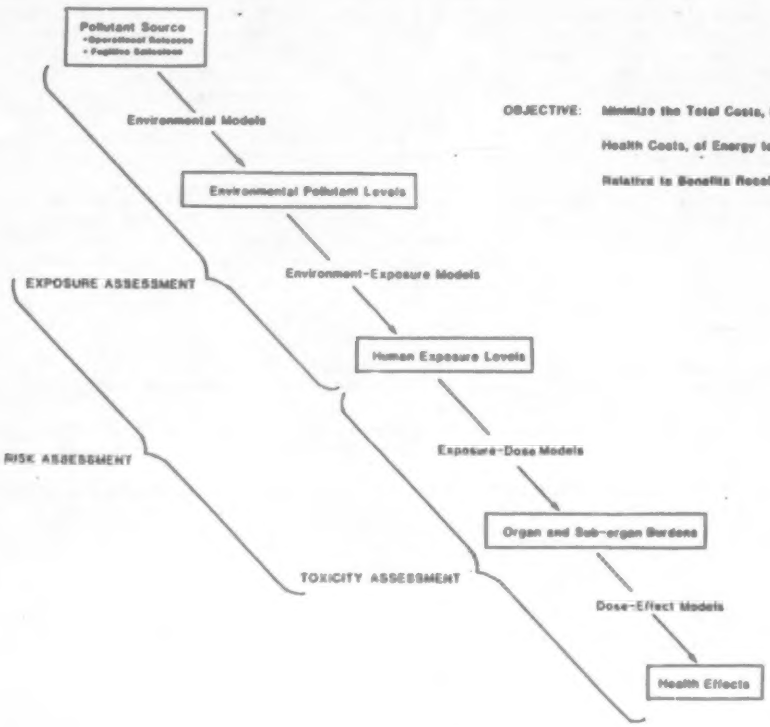
The energy technology orientation should range from consideration of those now in use (eg, coal combustion and nuclear power), to those with near to intermediate term application (eg, coal gasification and liquefaction, oil shale) to those that may be important in the next century (eg, fusion). Consideration should be given to all energy producing, consuming and conserving activities. This of necessity includes such diverse activities as mining and retorting of oil shale, production and use of photo-voltaic devices, distribution and use of synthetic fuels, disposal of wastes and use of man-made insulating materials. The research should address exposures of both workers and the general public.

I favor a research program that is strongly oriented to providing information that will allow assessment of health risks in people as illustrated in the attached figure. This orientation recognizes the importance of developing knowledge of pollutant sources and levels resulting from operational, fugitive and accidental releases. It requires characterization of these materials in the workplace, indoor and general environment with special reference to their form when they reach man. In this area, special care must be taken to separate the consequential from the non-consequential recognizing that everything that is measurable does not necessarily pose a health risk and that energy-related pollutants are only a part of the total environment.

The next logical area of concern is how pollutants enter and are distributed within the body following inhalation, ingestion or other forms of exposure. This area of research should be oriented toward establishing an understanding of the relationship between exposure and the concentrations of materials that are available for interaction with critical organelles, cells and tissues and the pollutant, environment and host factors that influence this relationship.

The next area of research is directed toward understanding the cause-effect relationships between tissue concentrations of individual pollutants and mixtures and diseases in man. In considering which pollutants or mixtures to study, priority should be given to those encountered or likely to be encountered in high concentration by man and those with high likelihood of producing deleterious effects. The research should address a wide range of health effects from those that are viewed as temporary physiological alterations to those that are irreversible and permanently impair an individual's physical or mental abilities and those that impact on future generations. Because most occupational and environmental exposures to energy-related pollutants are at low levels, the emphasis within the research program should be on late-occurring diseases.

INTEGRATED APPROACH TO EVALUATING HEALTH RISKS OF ENERGY TECHNOLOGIES


Pollutant Source
•Operational Releases
• Fugitive Emissions
Environmental Models
Environmental Pollutant Levels
Environment-Exposure Models
Human Exposure Levels
Exposure-Dose Models
Organ and Sub-organ Burdens
Dose-Effect Models
Health Effects
EXPOSURE ASSESSMENT
RISK ASSESSMENT
TOXICITY ASSESSMENT

OBJECTIVE: Minimize the Total Costs, including Health Costs, of Energy to Society Relative to Benefits Received

The research program should seek to take advantage of any human exposure situations that provide the opportunity to better understand the induction of diseases by energy pollutants. However, recognizing that such opportunities are fortunately limited, the majority of the health-related research must be conducted in other species and include studies at whole animal, organ, tissue and lower levels. The studies performed should include observations in systems (such as bacterial mutagenicity assays) that serve as possible predictors of late-occurring effects to systems that seek to directly identify late-occurring effects. Of necessity, effort should be directed to validating the capability of short-term tests for predicting the induction of late-occurring effects in laboratory animals and man and for extrapolating from laboratory animals to man.

The nature of the materials studied should span from specific elements or compounds to complex mixtures of materials identical to or mimicking those encountered or likely to be by man. Materials obtained directly from representative energy processes should be studied whenever they are available. However, a balanced approach must be taken to avoid pre-occupation with samples that are uniquely related to a specific process or site unless they are worthy of attention in their own right.

Recognizing that pollutants arising from energy technologies are only a part of the environment faced by people, it is important to investigate the potential interactions with other factors in the environment that may contribute in producing disease. Likewise, it is important to evaluate the influence of host factors such as age, occupation, social habits as well as health and nutritional status.

The program should include a balance of research directed toward (a) development of a basic understanding of how the body handles and responds to energy pollutants, (b) the development of improved techniques for studying pollutant behavior and effects, and (c) the conduct of both short- and long-term toxicity assays of energy pollutants.

I view formalized risk assessments as an important part of the total research program. Such assessments provide a logical framework for assembling, analyzing and interpreting all of the available information that is relevant to estimating the health impacts of any energy process or technology. The estimated risks represent an integration of the products of the research effort. Moreover, they fill a valuable role in identifying information gaps, and therefore, research needs.

In summary, the DOE needs a health and environmental research program that sharply focuses on developing information needed to assess the health and environmental impacts of conventional and new energy technologies. A balanced program that includes studies of man, laboratory animals and simpler systems is necessary recognizing that adequate information on man per se is not available. The complexity of the issues being addressed requires research to be conducted in several diverse areas. Provision must be made for information from the several areas to be integrated including a joining of environmental and health-related information. To meet the needs of the Department on a long-term basis, some of the research will of necessity focus on a single energy technology, some will be applicable to several technologies while other will be of a supporting nature.

I will be pleased to discuss with you in greater detail my views on specific aspects of the research program including my priorities for research needed to assess the health impacts of energy technologies.

Testimony Submitted To The

Subcommittee on Natural Resources, Agriculture Research and Environment

# of the

Committee on Science and Technology
U.S. House of Representatives

March 11, 1982

Warren K. Sinclair
National Council on Radiation
Protection and Measurements
Bethesda, Maryland 20814

My name is Warren Keith Sinclair. I reside at 2900 Ascott Lane, Olney, Maryland and I have a Ph.D. in Physics and a background in biophysics and radiobiology. I am presently employed as the President of the National Council on Radiation Protection and Measurements a private, not for profit corporation, chartered by the Congress of the United States, which publishes reports on all aspects of radiation protection. I am on leave from my position of Senior Biophysicist at Argonne National Laboratory where I was also until recently Associate Laboratory Director for Biomedical and Environmental Research and from my position as Professor of Radiation Biology at the University of Chicago, positions which I have held for 22 years. My personal experience in research has included a variety of studies in medical physics with both radionuclides and beam radiation, in biophysics and radiobiology on animal and cellular aspects of radiation effects, and in radiation protection and human risk estimation.

I should also say that I am a member of the International Commission on Radiation Units and Measurements, a member of the International Commission on Radiological Protection, and a member of the U. S. Delegation to the United Nations Scientific Committee on the Effects of Atomic Radiation.

In this discussion I shall concentrate mainly on achievements, ongoing research and some future needs in cellular radiobiology. I shall make reference also to some limited aspects of animal research and human risk information as they relate to radiation protection. I hope it is appreciated that I can only deal with a small cross section of a huge area of radiation research. Much of what I shall describe has depended on the funding support of the Office of Health and Environmental Research of the Department of Energy and its predecessors.

CELLULAR RADIATION BIOLOGY

The most important problems in radiation effects studies today concern the effects of very low doses of radiation, a problem in which cellular radiobiology can now play a very special role. First we must consider some of the critical steps in our understanding of cellular radiobiological processes. These include the study of cell killing, which while it relates more especially to the problems of the acute effects of radiation and to problems in radiotherapy, nevertheless, is necessary in order to understand and address problems of low dose effects.

Since the discovery of ionizing radiation in 1895, much theoretical and experimental work has been undertaken on the responses of cells to ionizing radiation and the manner in which cells are killed or otherwise damaged. In the first half of this century the principal cellular systems available for testing theories and examining responses were single celled organisms, microorganisms especially. These cells are important in many contexts and especially perhaps, to our understanding of molecular mechanisms in genetics and cancer induction, but they are not directly relevant to responses in human beings.

Mammalian Cell Cultures: Cell Killing A dramatic change took place in 1955 when Puck and Marcus, two scientists at the University of Colorado, developed a technique for examining human cells in culture that enabled the response of each individual cell to be examined in the same way as that previously reserved for microorganisms. The first of the responses to be documented was cell killing illustrated in the first Figure, which shows two culture dishes, each of which was inoculated with the same number of single cells; one was irradiated and the other was not. The single cells grew into colonies on the first unirradiated dish (a), while only very few colonies grew on the second irradiated dish (b) because the cells had been killed by the irradiation when they were single. If the dose had been higher, fewer colonies yet would be seen; if lower, more colonies would have survived. Thus, we have a dose-response relation between the level of the radiation dose and the number of cells killed.

Repair of Radiation Damage in Cells This initial technique led to many new discoveries about the properties of mammalian cells and their responses to radiation. A most important phenomenon is that of repair in cells. If a dose of radiation is given, some cells are killed and others are damaged. If another dose is given at once, the damaged cells will also die but if a time (a few hours) elapses in between the two doses, many of the damaged cells repair the damage and thus, fewer die from the second dose of 250 R when there is a time interval between doses (Figure 2).

Cell Cycle Another most important phenomenon occurs in cells. Cells in certain tissues in the body are always multiplying and they do so at a constant characteristic rate, e.g. cells in the gut double every 12 hours: This is called the generation time. During this generation time a cell goes through its entire "life" or "cell" cycle!

The cell performs all the biochemistry and other processes needed to double the genetic material of the cell, the chromosomes, the amount and type of proteins and so on, so that at the end of the generation cycle, the cell has twice as much of everything it had in the beginning. It does this discontinuously but in a well ordered sequence; a sequence incidentally, elucidated mainly by the application of radioisotope tracers, the use of which has been vital to our understanding of these basic cellular processes. One sequence is shown in Figure 3. A fresh daughter cell initially makes no new genetic material during Gap 1 then suddenly starts to create more DNA during the S period and duplicates all of the genetic material of the cell, every chromosome (46 in a human) in a careful order, in about 6 hours; when that is complete, the cell goes into Gap 2 where it duplicates no more genetic material but prepares for cell division. At the point of mitosis or cell division, the mother cell contains exactly twice as much material as the original fresh daughter. It now divides quite carefully, in about 40 minutes, in a process known as mitosis, into two daughter cells, each just like the first one we started with. A most elaborate, incredible and engaging process, the cell cycle!

Important to us in radiobiology is that the cell differs in sensitivity at different stages of the cell cycle. In Figure 3 are the responses *to the same dose*, of cells at all stages of the cell cycle (*asynchronous*) which are intermediate or average in sensitivity; cells at a late stage in the synthesis of the genetic material, i.e. cells at the *late S* stage which are very resistant and survive radiation well; and then cells during division or *mitotic cells* when they are extremely sensitive to radiation so that small doses kill them easily. These phenomena were discovered by the technical trick of synchronizing cell populations, that is obtaining cells all at the same stage in the cell cycle, a technique I have had much to do with personally and my work on this was entirely supported by the DOE-OHER programs at Argonne in the 1960's.

Oxygen Effect and Other Modifiers Systems of cell cultures also enabled us to examine the effect of many important physiological conditions on cell responses. For example, the presence or absence of oxygen in cells had a profound influence on the radiation response; well oxygenated cells are sensitive to radiation and easily killed, cells without oxygen (anoxic) are resistant and not easily killed (Figure 4).

Radiation Therapy of Cancer All of the above has an important bearing on radiation therapy and our understanding and improvement of it: (1) Because of the timing of repair in normal and cancer tissue, we know that fractionation in therapy is important, (2) we also know from experience with synchronized cells that the time in the cell cycle is important, (3) because tumors contain anoxic, resistant cells, we know we must irradiate these either with additional O_2 present, or oxygen simulating drugs, or by using high LET (neutron, pion or heavy particle) therapy where anoxic cells matter less and (4) we are able to apply, from studies in the cell culture dish, additional chemicals, often cell cycle dependent, that help the radiation to kill cells preferentially. This very important part of cancer treatment and the vast improvement in radiation therapy in this country over the past twenty or thirty years has depended and still depends, on the programs of cellular radiobiology supported by DOE and by NIH in the Laboratories and the Universities.

Acute Radiation Syndrome Another most important application of these cellular radiobiological developments is in our understanding of what is known as the acute radiation syndrome. When human beings are exposed to high doses of radiation, as the people of Hiroshima and Nagasaki were and as some others have been in accidents, they will experience acute effects. Broadly, the type and extent of the acute effects depend on the magnitude of the dose received (See Figure 6). The higher the dose the more rapidly is a human being killed and different clinical responses occur at different doses. We are also broadly aware of protective agents that modify this syndrome and sensitizing agents that enhance it.

Programs like the REACTS program at Oak Ridge Associated Universities, supported by DOE, include a knowledge of how to treat acute syndromes and thus, save some people who would otherwise die. Our understanding in this field comes from cellular radiobiology, animal radiobiology and limited human experience. I need hardly say how important all this would be if a nuclear disaster were to strike us. Our knowledge and our capacity to deal with disaster are incalculably affected by this kind of research.

LOW DOSE EFFECTS AND CELLULAR RADIOBIOLOGY

While the problems relating to effects in cells and organisms such as radiation therapy and the acute radiation syndrome are important, much more challenging yet in todays science is the determination of low dose radiation effects, principal among these are those (somatic) effects occurring in human tissues which give rise many, many years later to cancer in that tissue. Also important are genetic effects which are passed on via our reproductive cells and burden successive generations with increased genetic handicaps. Both somatic and genetic effects occur at comparatively low doses, although more frequently the higher the dose. While there *may* be a threshold for these effects at very low doses (we can't be sure there isn't) the available scientific evidence must incline us to play it safe. Thus, we assume that at all dose levels, some risk of both somatic (cancer induction) and genetic effects occurs.

The evidence about the risks of cancer (I will discuss cancer induction and leave genetic effects, important as they are, to others to discuss) comes from three interwoven and mutually dependent research fields: (a) human epidemiological studies, (b) animal radiobiological research and (c) mammalian cell research. Although I intend to concentrate on (c) because that is my own special, personal expertise, I will make a few remarks also about (a) and (b) because all three are relevant to the information needed by the National Council on Radiation Protection and Measurements. The Council makes judgements about appropriate levels of radiation exposure for occupational radiation workers, for members of the public and for emergency conditions.

(a) HUMAN EPIDEMIOLOGICAL RESEARCH

Populations exposed to ionizing radiation constitute the main resource here. These populations include (Figure 7) the Japanese survivors of the atomic bombs, patients irradiated therapeutically, in fluoroscopy of tubercular patients, U. S. and British radiologists, etc. The evidence from these sources, much of which is still accumulating and sometimes being modified, is constantly under examination by groups such as NCRP and also by groups such as UNSCEAR (Figure 8) and the recent BEIR Committee (Figure 9). From their examinations, these committees attempt to derive risk rates for each of the different cancers and for all cancers as a function of the dose.

Why does the evidence need constant examination? Much information is still accumulating in studies such as the Japanese. Also, sometimes older information is modified as well as new information developing from additional populations that come under study. All information must be factored in to an overall assessment. Let me just give, by way of example, two features of the study of the Japanese populations. (1) It is 36 years since the bombs were dropped in 1945 but the latest assessments of the UNSCEAR (1977) and BEIR (1980) used the information on mortality from cancer and tumor incidence at Hiroshima and Nagasaki up until 1974. Since that time, during the past year, from the continuing research of the Radiation Effects Research Foundation which DOE-OHER supports, the data from the period 1974-78 has been added. Since the latent periods for many tumors except leukemia are very long, more tumors are appearing now in the 1974-78 period than in any comparable earlier period. There may be even more in the 1979-1983 period, we don't know yet. These additional periods of study represent very, very important information, and must continue in the years to come until all the survivors are dead, which will be beyond many of our life spans, certainly mine since I was 21 when the bombs were dropped and many of the survivors were much younger. Even thereafter, there may still be studies to continue for genetic information if acceptable techniques are available.

(2) Recent investigations stimulated by the NCRP have led to a number of the DOE laboratories becoming involved in a reinvestigation of the doses to which the survivors were actually exposed. It appears that the previous efforts to estimate the dose in 1965, known as T65D, although carefully done, were based on certain assumptions about the spectra of radiation issuing from the weapons and transport equations for dose vs distance. New information and modern techniques indicate that these can be improved. The initial thrust of the reinvestigations is that the relative neutron and gamma doses at Hiroshima will be altered very substantially; the neutrons downward by (6 - 10 x) and the gamma doses upward by (3 - 4 x). These investigations are absolutely vital to establishing our best estimates of the doses and therefore, the risks per unit dose from this most important of all the human sources of information. DOE is properly expanding support for efforts on the resolution of these problems.

Epidemiology has its limitations and one important one is that at very low doses, huge numbers of exposed people and exactly comparable unexposed controls are needed to assess effects. We do not have suitable populations which have been exposed at low doses and so we must "extrapolate" from information at much higher doses. Very little human information is available to do this, so we must rely on animal research and on cellular research to provide the dose effect information for us.

(b) ANIMAL RESEARCH AND RADIOBIOLOGY

I will not attempt to cover all the enormous work painstakenly developed in long term animal research on the induction of tumors by radiation, most of it in the laboratory mouse, some in longer lived animals like the dog (which is much more like man than the mouse, you may be pleased to know!). I will illustrate our reliance upon the animal research by the following example: One dose effect relationship, based on theory but with much experimental support, suggests that at low dose, and dose rates, the cancer induction rates are substantially less per unit dose than at high dose rates where the data in humans mostly exist. They can be expressed in the form of a ratio, a dose rate effectiveness factor (DREF). One of the Committees of the NCRP studies this matter in great detail and produced a report which examined all the data available, cellular as well as animal, and concluded that for many, many systems and probably applicable to humans, this DREF was between 2 to 10 times (Figure 10). Thus, in most instances, the real risk of human cancer at low dose is probably 2 to 10 times less than we suppose or can estimate from data at higher doses. This is an important finding. It took an enormous amount of research to provide the information the NCRP Committee assessed so carefully. I take this one example from an enormous plethora of research information generated in animals to supplement our meagre human information.

(c) CELLULAR RADIOBIOLOGY

In the low dose field the effects of interest are cancer induction and genetic effects. Each has their counterpart in the mammalian cell culture system, in the form of transformation of nonmalignant cells to malignant and in the mutation of various cells to new genetic properties. I will not deal with the fascinating and very important field of mutagenesis at the cellular level but I will concentrate on transformation in cells. Studies of the transformation process in cells developed only in the late 1960's and were prosecuted slowly in research laboratories since, experiments were expensive in time and money, though less costly than animal research.

Transformation occurs in nonmalignant cells of primary cultures spontaneously, or as the result of induction by chemical carcinogens or radiation. Detecting transformed cells is one of the ways we have of recognizing whether an agent is cancer inducing. Shown in Figure 11 is a culture dish with untransformed (A) and a transformed colony (B). The untransformed cells grow in a controlled fashion and will not cause a tumor if transferred back into the host animal; the transformed cells grow in an uncontrolled fashion and will cause a tumor if injected back into the host animal. Another example of transformed cells is shown in Figure 12.

A variety of different cellular systems of other types have been used to study the effects of radiation (chemicals) in producing transformation (= cancer). One important phenomenon studied effectively in one of these systems is shown in the next figure (13). This shows that high dose rate is more effective than low dose rate and confirms the DREF of 2 - 10 (this is about 8) we noted above for many animal systems. It also means that repair mechanisms must be operative, i.e. that damage leading to transformation can be repaired if time elapses between doses. This should have an important bearing on our understanding of the molecular mechanisms leading to transformation, which is ultimately necessary for us to understand the cancer process and perhaps then to control it.

Low Dose Cellular Studies Extending the cellular technique to low doses is difficult, as it is with human and animal studies, but it has been attempted. Some potentially unpleasant surprises with important implications for radiation protection have resulted so far. The nature of them is shown in Figure 14 in the work of Hall and others at Columbia University, again supported by DOE and NIH. These data indicate that at low doses the transformation rate following x irradiation, instead of falling uniformly and evenly to zero, appeared to level off and fall much more slowly, indicating a potentially higher risk rate than might be estimated by the linear hypothesis.

Some further work by Elkind and colleagues at my former laboratory, Argonne National Laboratory in Chicago, also supported by DOE, while not confirming the work of Hall for x and γ radiation, discovered another anomaly in the response of neutrons (Figure 15). Neutrons are not usually very dose rate dependent and for cell killing low dose rates and high dose rates are equally effective. However, in a study in which the dose levels for transformation effects were examined using both a high dose rate and a low dose rate, Elkind, et al, found the lower dose rate the more effective in the low dose region. Again, implying a higher risk rate at low doses than we would anticipate from simple linear evidence.

Yet again, (Figure 16) the influence of agents such as 12-0-tetradecanoyl-phorbol-13-acetate (TPA) which effect radiation responses turns out to have different effects, at low doses, on the x ray response and the neutron response and therefore, to modify the ratio between them in a complicated way.

It should be emphasized that these results at low dose, while they seem convincing enough in themselves, come from very difficult experimental techniques and conditions and may be subject to errors hitherto not expected by any of us. Nevertheless, at this point in time, until we understand them much better, they represent a worrying, difficult and "must be evaluated" problem to those like myself who feel that risk estimation based on other sources is otherwise comparatively sound and probably all within the bounds of uncertainty we have come to expect. These important matters must be resolved and as expeditiously as possible.

CONCLUSION

Let me conclude this presentation by pointing out to you that this quite lengthy discourse has touched on only a few of the problems that bear on our knowledge of radiation protection today and the scientific base that we have to use for recommendations on human safety.

Nevertheless, at all the levels we must draw from to obtain a more complete picture of the effects of low dose radiation on people, cellular, animal and human data themselves, the DOE-OHER program has been a major supporter and its funding and its choices of problems for support has been critical to the work of the NCRP and to the nation as a whole. Our knowledge has advanced enormously because of that support but it is still very imperfect and the support must continue, at the maximum level possible, if we are to solve some of the very significant gaps in our knowledge that I have mentioned today.

ILLUSTRATIONS

1. Radiation Effects

2 Dishes:	one unirradiated	100 - 200 clones
	one 500 r	5 - 10 clones

2. Repair

3 Dishes:	one unirradiated	100 - 200 clones
	one irradiated 500 R	5 - 10 clones
	one irradiated 250 + time + 250 R	20 - 30 clones

3. Cell Cycle

3 Dishes:	one asynchronous	20 - 30 clones
	one late S.	100 - 200 clones
	one mitosis	5 - 10 clones

4. Oxygen Effect

3 Dishes:	one irradiated	100 - 200 clones
	one 500 R oxygen	5 - 10 clones
	one 500 R anoxic	30 - 40 clones

5. Radiotherapy and Cellular Responses

6. Acute Radiation Syndrome and Emergency Health Procedures

7. Populations Exposed and Used as Source of Risk Estimation

8. UNSCEAR Report (1977)

9. BEIR Report (1980)

10. NCRP Report 64

11. TRANSFORMED CLONES

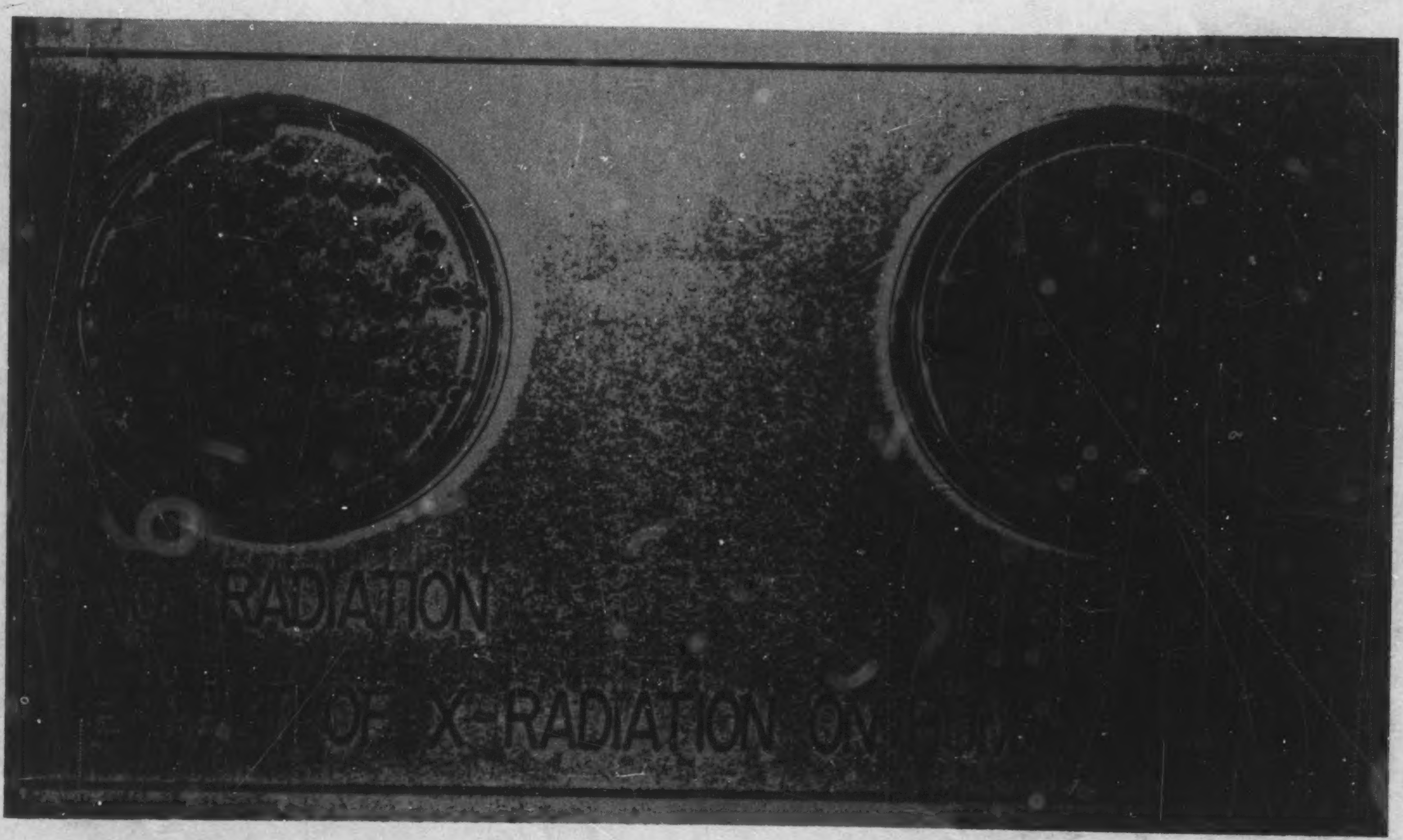
12. TRANSFORMED CLONES

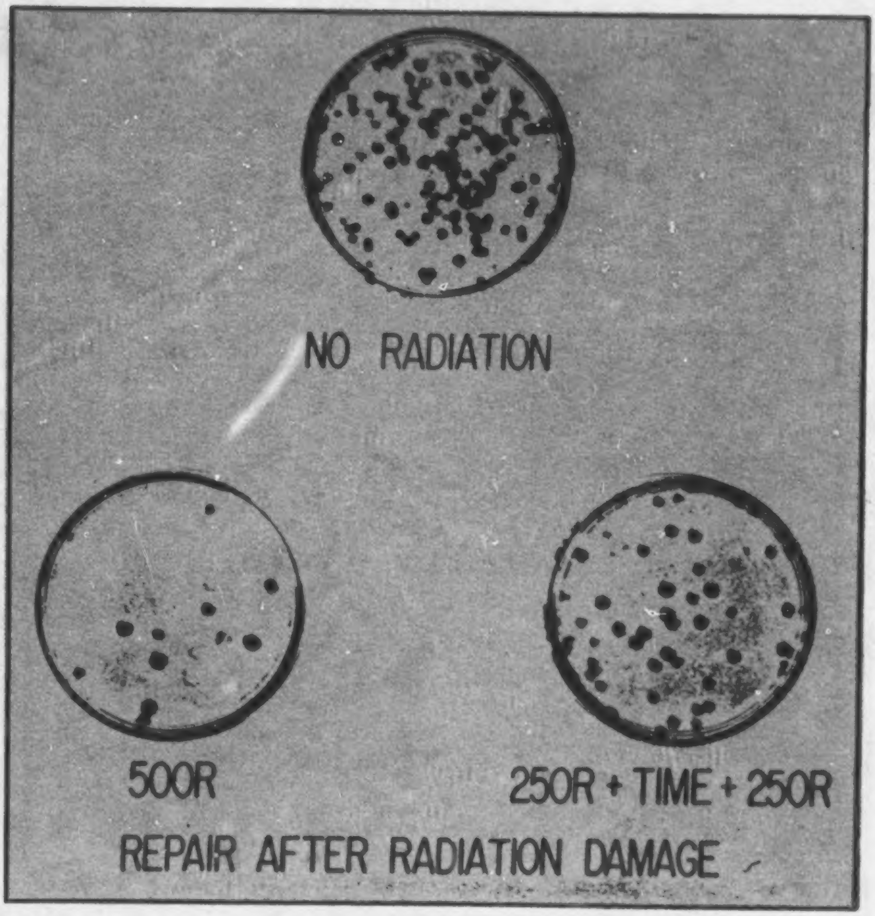
13. Effect of Dose Rate on Transformation

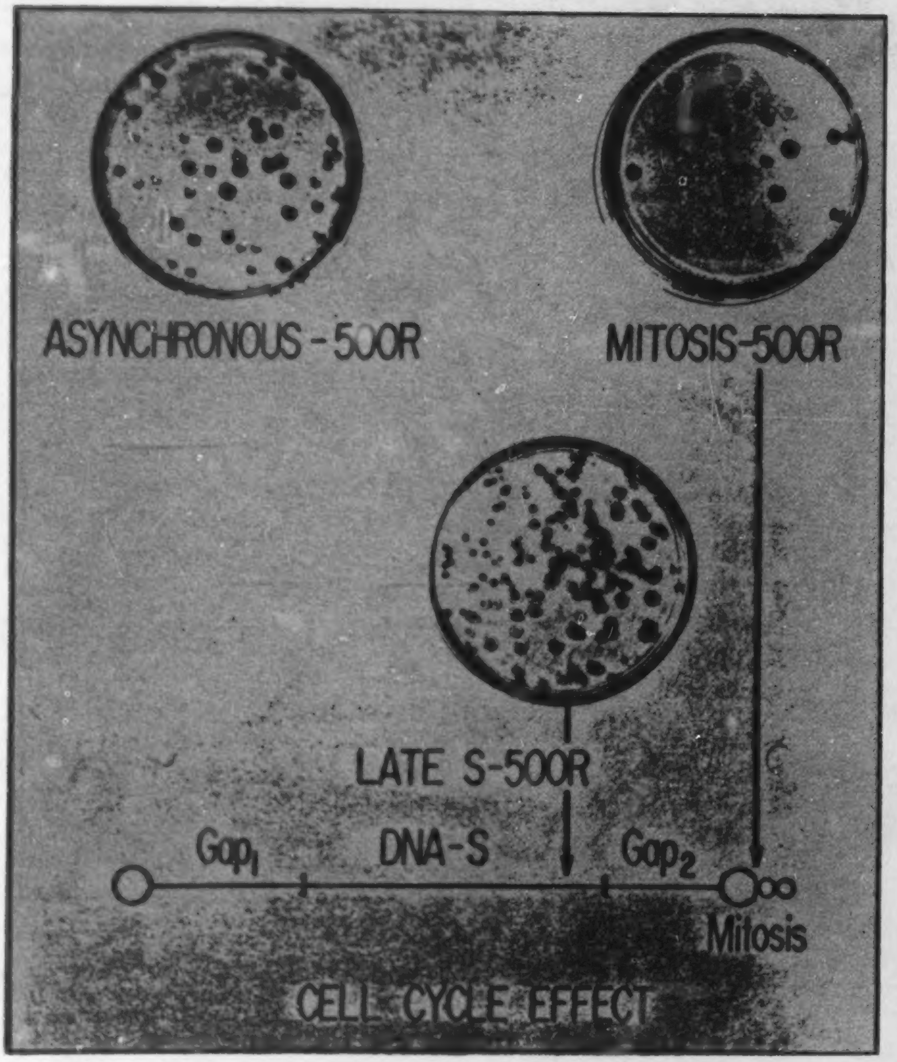
14. Transformation at Low Doses (x rays - Miller & Hall)

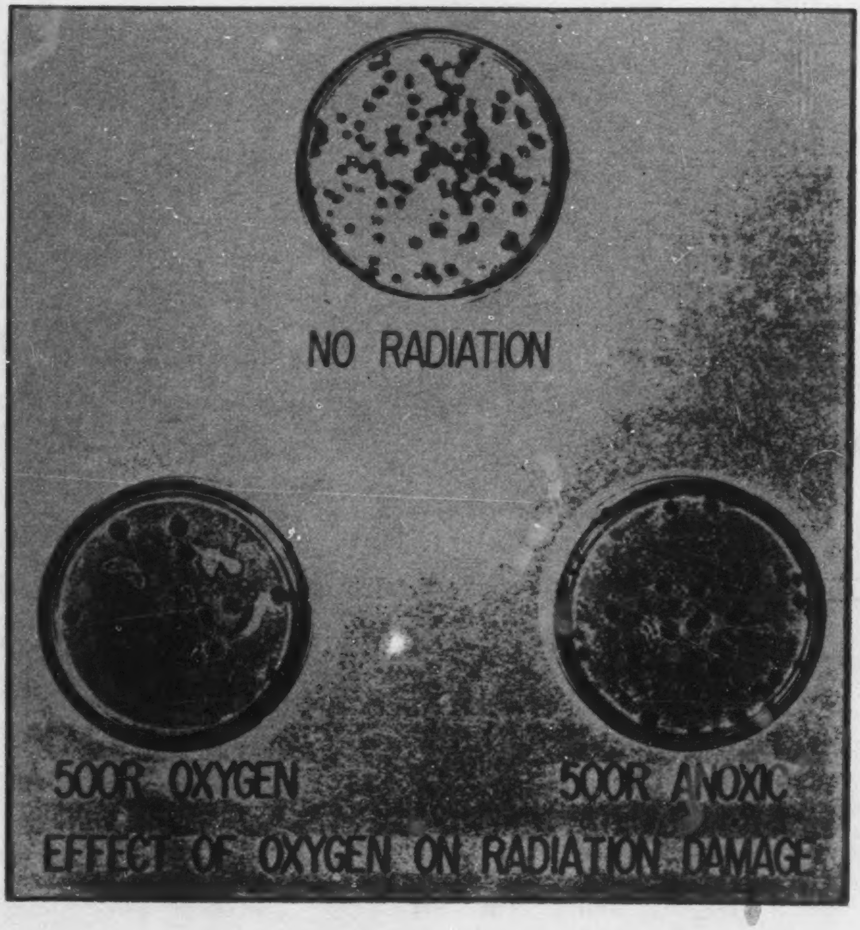
15. Transformation at Low Doses (neutrons - Elkind, et al)

16. Effect of TPA on n/x RBE


RADIATION
OF X-RADIATION ON


NO RADIATION
500R
250R + TIME + 250R
REPAIR AFTER RADIATION DAMAGE


ASYNCHRONOUS - 500R
MITOSIS-500R
LATE S-500R
Gap$_1$
DNA-S
Gap$_2$
Mitosis
CELL CYCLE EFFECT


NO RADIATION
500R OXYGEN
500R ANOXIC
EFFECT OF OXYGEN ON RADIATION DAMAGE

RADIOTHERAPY AND CELLULAR RESPONSES

Repair → Fractionation

Synchrony → Cell Cycle Effects

Oxygen → Anoxic Cells in Tumors Are Resistant

Chemical Modifiers → Enhance Radiation Effects

ACUTE RADIATION SYNDROME

>5000 - 10,000 R	NERVOUS SYSTEM DAMAGE SHOCK, COMA, DEATH 1 - 2 D
>1000 R	GASTROINTESTINAL SYNDROME LOSS OF FLUID AND CELLS DEATH 3 - 10 D
>300 R - 500 R	NAUSEA AND VOMITING, CHILLS, INFECTIONS BLOOD COUNT DEPRESSION DEATH (50%) IN 30 DAYS
<200 R	NO DIRECT EFFECT, BLOOD CHANGES (LATE EFFECTS LATER)

SOURCES OF HUMAN EXPOSURE INFORMATION

Japanese Survivors of A-Bombs

Marshall Islanders Exposed to Fallout

Pelvic Radiotherapy

Spinal Radiotherapy (Ankylosing Spondilitis)

Neck and Thyroid Radiotherapy

Scalp Irradiation (tinea capitis)

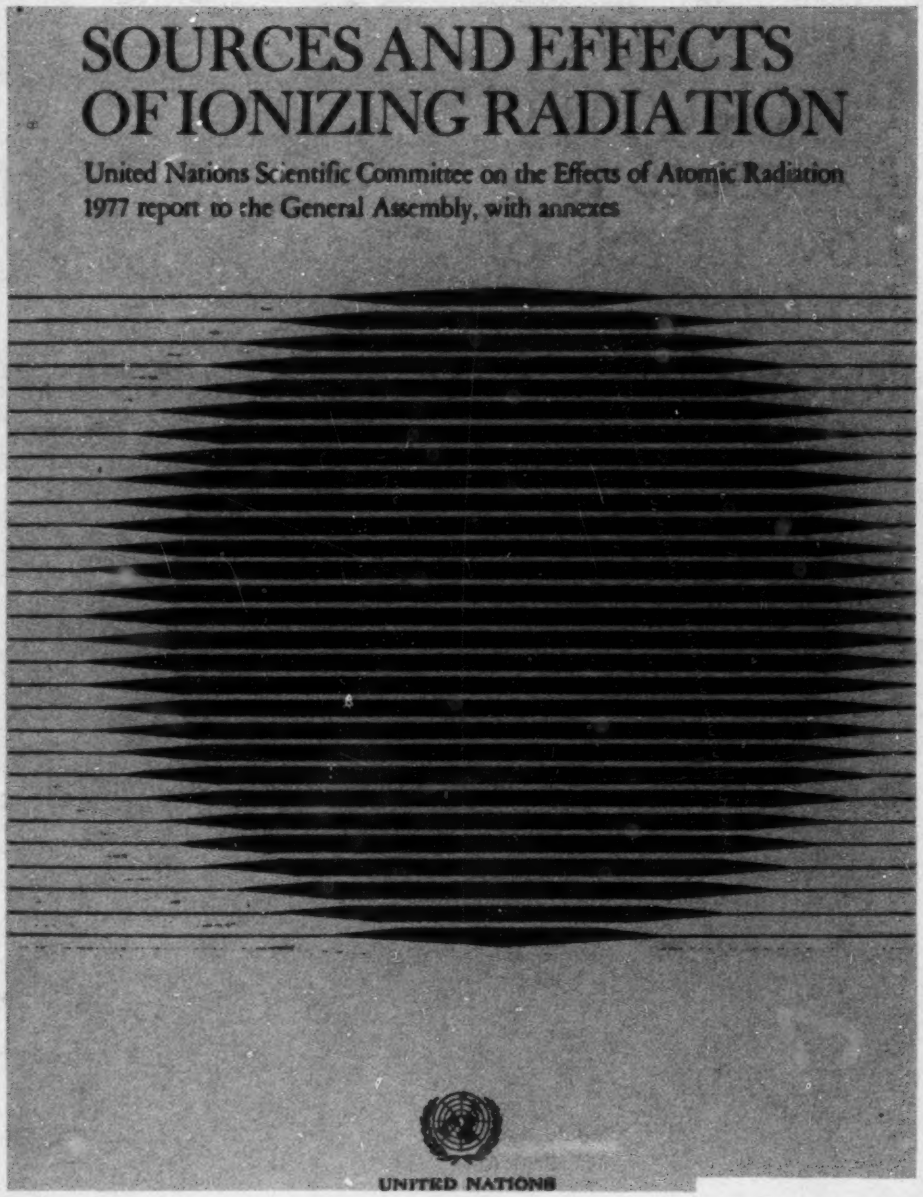
Breast Radiotherapy

Multiple Fluoroscopies

Uranium Miners

Radium^{226} Ingestion

Radium^{224} Treatment



SOURCES AND EFFECTS
OF IONIZING RADIATION

United Nations Scientific Committee on the Effects of Atomic Radiation
1977 report to the General Assembly, with annexes

UNITED NATIONS

The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980

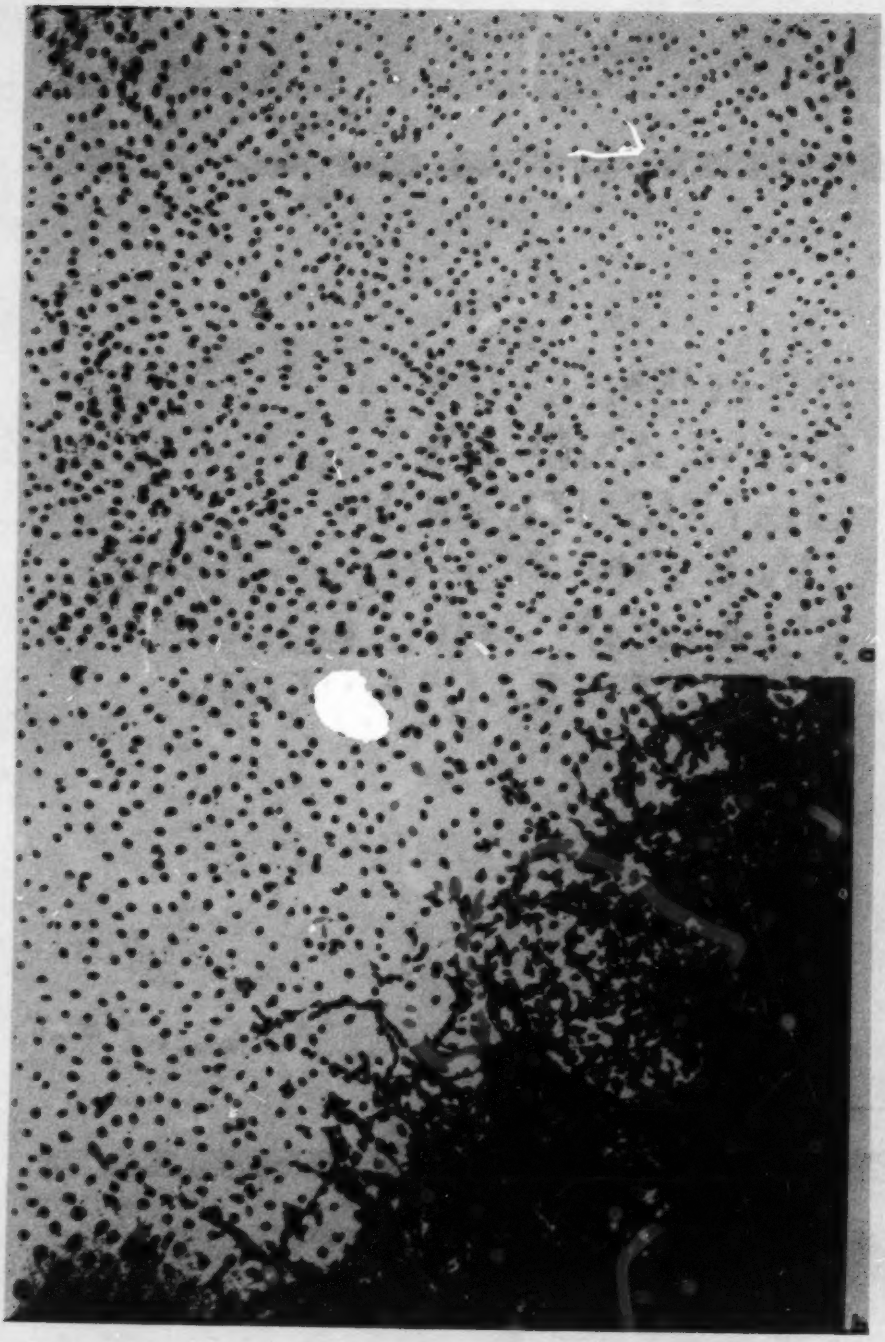
NRC NAS NAE IOM

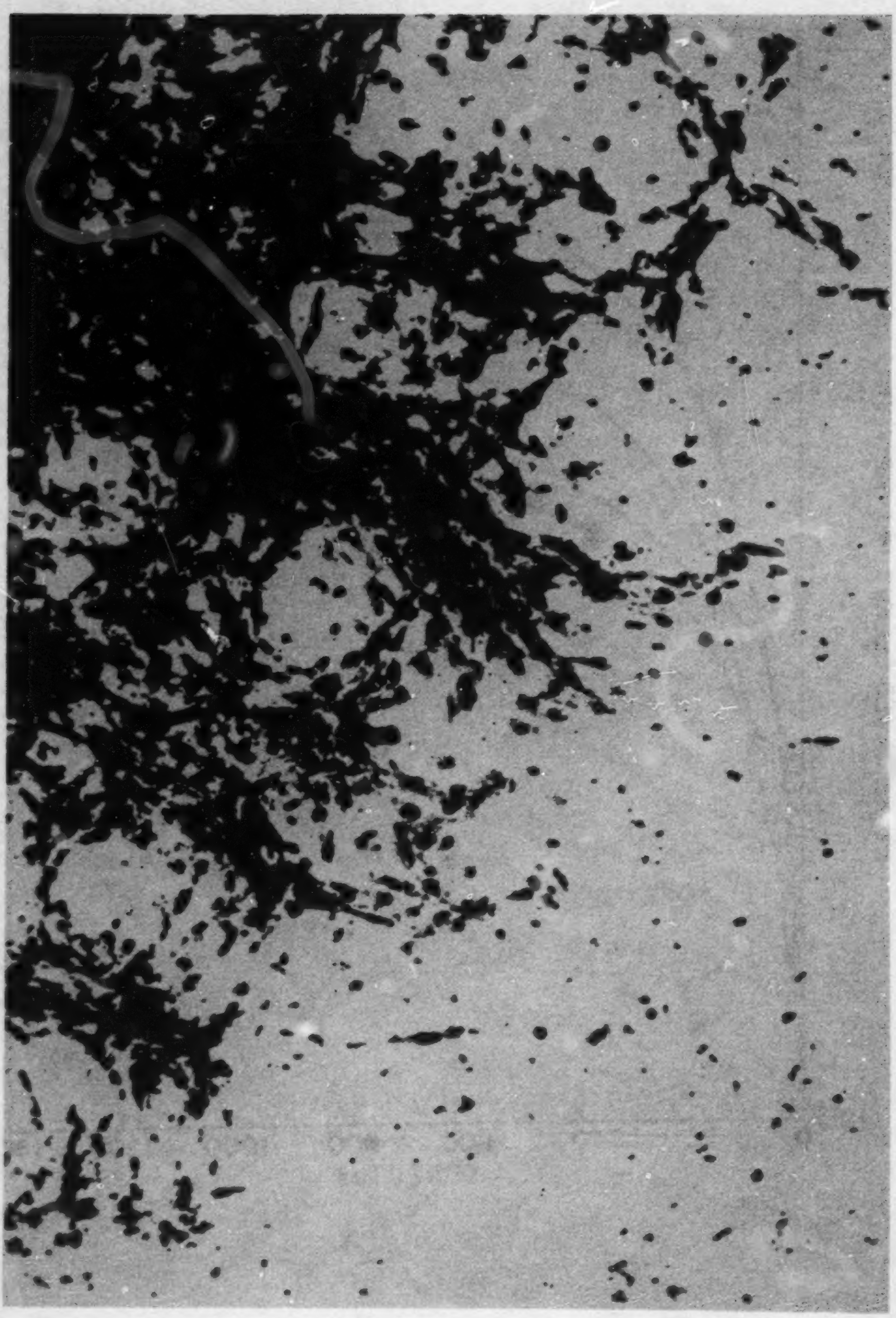
NCRP REPORT No. 64

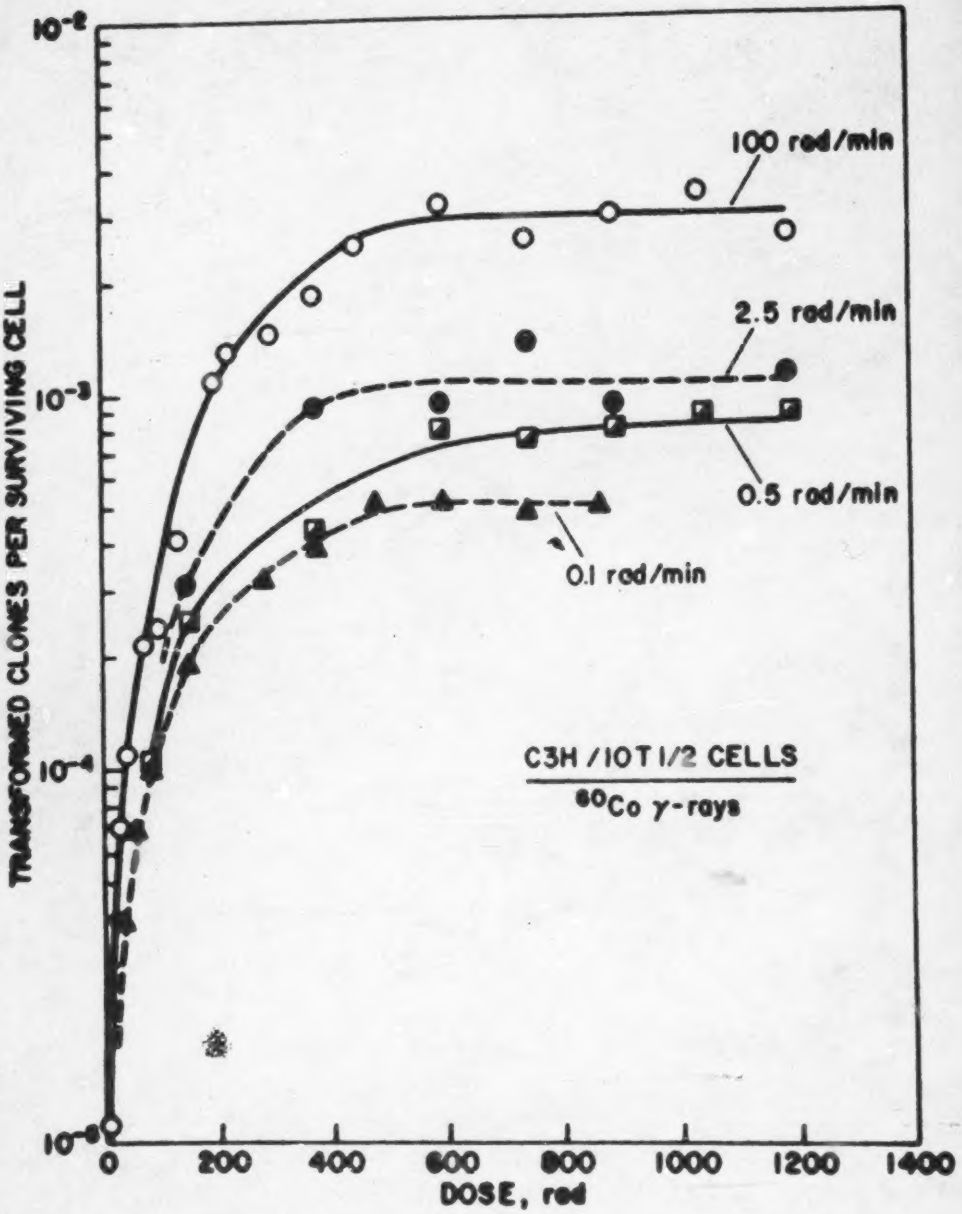
INFLUENCE OF DOSE AND ITS DISTRIBUTION IN TIME ON DOSE-RESPONSE RELATIONSHIPS FOR LOW-LET RADIATIONS

NCRP

National Council on Radiation Protection and Measurements


a
b





TRANSFORMED CLONES PER SURVIVING CELL
10^-2
10^-3
10^-4
10^-5
0
200
400
600
800
1000
1200
1400
DOSE, rad
100 rad/min
2.5 rad/min
0.5 rad/min
0.1 rad/min
C3H / 10T 1/2 CELLS
60Co γ-rays

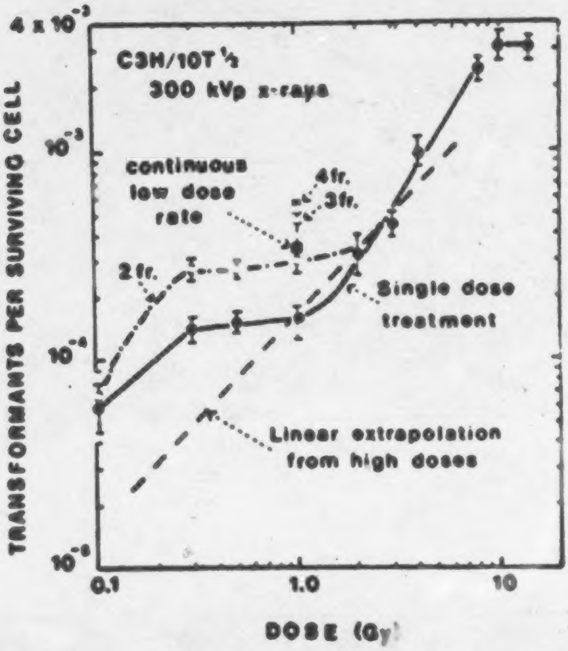
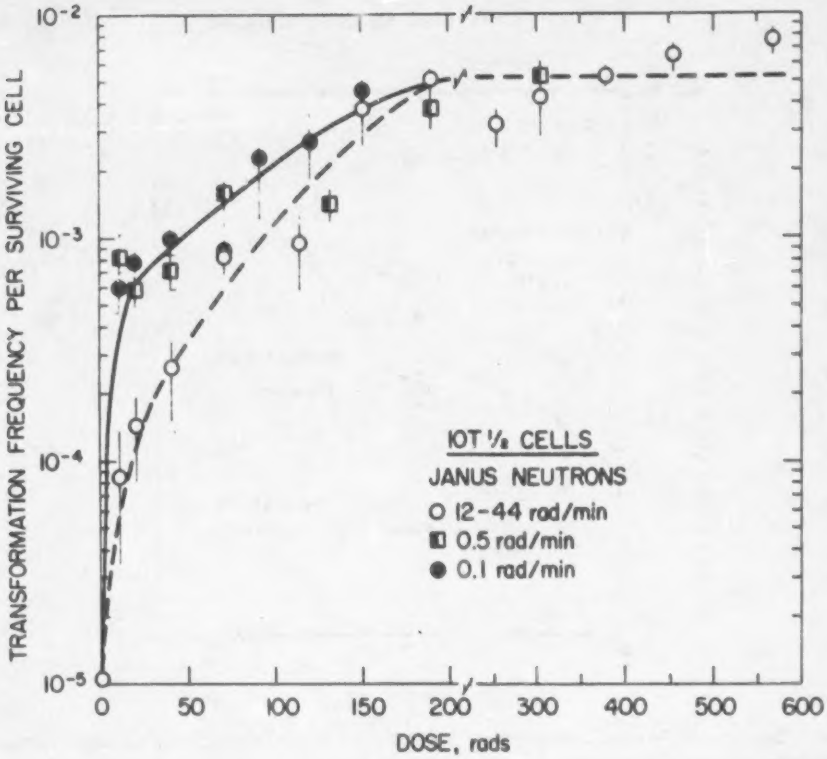
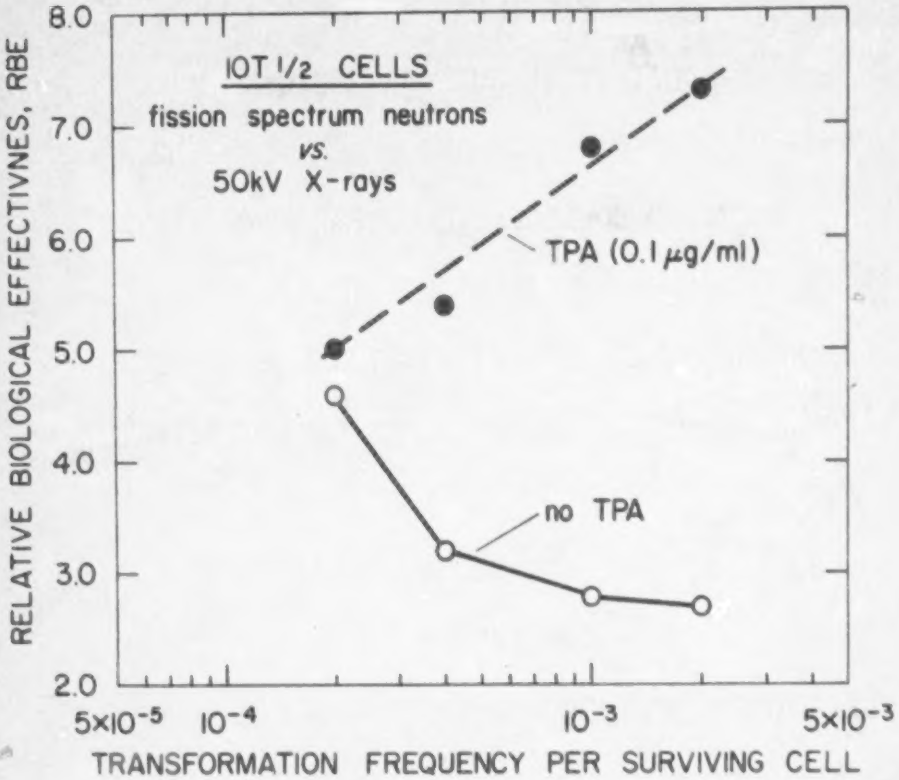


FIG. 9. Summary of the transformation data for single acute doses of X rays, fractionated X-ray doses, or low-dose-rate protracted exposure to γ rays, taken from Figs. 5, 6, 7, and 8. The dotted line illustrates that a linear extrapolation from data for high single doses results in an *underestimate* for transformation incidence at lower doses, which is exaggerated when the radiation is delivered over a period of time as a series of fractions or in a continuous low-dose-rate exposure.


10⁻²
10⁻³
10⁻⁴
10⁻⁵
TRANSFORMATION FREQUENCY PER SURVIVING CELL
0
50
100
150
200
300
400
500
600
DOSE, rads
10T½ CELLS
JANUS NEUTRONS
○ 12-44 rad/min
◨ 0.5 rad/min
● 0.1 rad/min


IOT 1/2 CELLS
fission spectrum neutrons
vs.
50kV X-rays
TPA (0.1 μg/ml)
no TPA
RELATIVE BIOLOGICAL EFFECTIVNES, RBE
8.0
7.0
6.0
5.0
4.0
3.0
2.0
5×10⁻⁵
10⁻⁴
10⁻³
5×10⁻³
TRANSFORMATION FREQUENCY PER SURVIVING CELL

STATEMENT OF THE
SOCIETY OF NUCLEAR MEDICINE
AND
AMERICAN COLLEGE OF NUCLEAR PHYSICIANS
FOR THE
HOUSE SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT
OF THE
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE
CONCERNING THE
DEPARTMENT OF ENERGY's FISCAL YEAR 1983 BUDGET

MARCH 10, 1982

Mr. Chairman, Members of the Committee, the Nuclear Medicine community sincerely appreciates this opportunity to provide information concerning the importance of basic nuclear research to the practice of nuclear medicine, and the vital contributions to this activity made by the Department of Energy's Environmental Research Program.

This statement is being submitted on behalf of the Society of Nuclear Medicine and American College of Nuclear Physicians. Both organizations strongly support the need to continue funding for nuclear medicine research through DOE. The College is a professional organization representing more than 1200 physicians and scientists who actively practice nuclear medicine. The Society of Nuclear Medicine is a scientific organization of 10,000 members including physicians, physicists, chemists, radiopharmacists, nuclear medicine technologists and other professionals whose careers involve the diagnostic and therapeutic use of radioactive materials in medical applications. The combined membership of these two organizations truly represents the Nuclear Medicine community in this country.

Mr. Chairman, the College and Society are fully cognizant of severe budget constraints that the Congress in general, and your Subcommittee in particular, must confront in addressing FY 83 budget needs. However, we believe that in the field of nuclear medicine the translation of basic research activities leads to health benefits and cost savings for the American public that more than justify the appropriation levels recommended by the Administration for this activity. Past research resulting from DOE's nuclear medicine applications program, designed to enhance the application of radioactive and rare-abundance stable isotopes in the diagnosis and treatmemt of human disease, has produced benefits that otherwise would not be available today. We trust the following information will assist the Committee in its deliberations on the budgetfor DOE's Environmental Research Program.

WHAT IS NUCLEAR MEDICINE TODAY?

Nuclear Medicine is the use of radioactive and some non-radioactive materials in the diagnosis of disease in humans. Patients frequently are seen by their physicians with signs and symptoms compatible with more than one disease, each of which requires different treatment. Good diagnostic medicine, therefore, is essential if the physician is to direct the management of the patient in the appropriate manner and avoid costly delays in selecting the correct treatment. Nuclear medicine techniques enhance good diagnostic medicine in a unique manner.

In the most common type of nuclear medicine procedure, the in vivo study, a very small amount of a radioactive preparation is administered to a patient, usually by injection. In many cases this radiopharmaceutical is specifically designed to concentrate in one body organ, or to be metabolized or removed from the body by a particular organ. In other instances the drug is designed to concentrate only in abnormal tissue such as a brain tumor or a myocardial infarct. The radioactivity emitted from the internally-located radiopharmaceutical permits sophisticated external instrumentation to record and image the distribution of the radioactive preparation in the organ selected for study. In many laboratories the data derived from the examination are also processed by computer, producing improved images and quantitative information about organ function. Most major organ and tissue systems of the body can be examined in this fashion, including the brain and central nervous system, lungs, liver, kidneys, bone, thyroid, pancreas, and the cardiovascular system.

These studies provide valuable information to the patient's physician. If the study shows that no abnormality is present, the patient can be reassured, possibly even discharged from the hospital, and the physician can turn his attention to other aspects of the patient's problems. If the study discovers that disease is present then the physician can turn quickly to the next diagnostic phase or perhaps begin therapy. In some situations, the unique information derived from the nuclear medicine study is life saving; in others, at the very least, it provides an efficient route to the best treatment possible under individualized circumstances. Further, it should be noted that nuclear medicine diagnostic procedures are safe and essentially painless for the patient; the only sensation being that due to the needle puncture when the radioactive preparation is administered.

Approximately 37 million persons are admitted to U.S. hospitals each year and more than 70 million nuclear medicine procedures are performed each year in hospitals and outpatient facilities. When one considers that, on the average, two nuclear medicine procedures are performed on every patient admitted to a hospital, the impact of this unique medical science on health care delivery becomes apparant.

HOW EFFECTIVE ARE NUCLEAR MEDICINE PROCEDURES?

The ACNP and SNM believe that nuclear medicine procedures, by improving and streamlining the diagnostic process, (a) reduce total health care expense, hospitalization, and patient suffering by rapidly directing patient management, and (b) provide, in many areas, more useful information about the patient's problems than that available from other diagnostic modalities, many of which are more costly. Because nuclear medicine procedures can study dynamic body processes such as heart, and kidney function, they can tell us what the body does or does not do, as opposed to other imaging procedures which only reveal anatomic information.

Nuclear medicine techniques are especially versatile for basic research in the chemical, biological, and physical sciences and, since technique is similar, data in these areas can be easily merged with clinical research allowing rapid transfer of information from the research laboratory to clinical practice. Specific examples document this assertion.

(A) Cardiac Nuclear Imaging

One of the most dramatic examples of the rapid transfer of nuclear medicine research developments from the laboratory to the hospital is the noninvasive study of coronary heart disease. Heart attacks kill approximately 700,000 people annually and are the leading cause of death in the United States. Almost 300,000 individuals suffer their first heart attack without prior knowledge of having coronary artery disease. Great strides have been made in treating coronary disease once it has been identified, but early identificaion of persons at risk has been particularly difficult to achieve. Nuclear diagnostic techniques that have been developed and applied in just the past four years are significantly more sensitive in identifying individuals with diseased coronary arteries than previously used methods as electrocardiographic stress testing or coronary angiography.

These important techniques have been the result of research programs directed towards developing improved detection instrumentation and identifying better radioactive tracer substances for studying the natural history of heart disease and the consequences of coronary artery narrowing on heart function. These newly developed nuclear diagnostic methods are being applied with increasing frequency in outpatient facilities where men and women in certain high risk categories can be screened for heart disease. Such techniques are also being used to assess the extent of damage after heart attacks have occurred. The routine use of these procedures has resulted in significant savings in medical care costs since the hospitalization normally required for the more extensive diagnostic tests such as cardiac catheterization is no longer necessary, and patients with similar symptoms but no actual heart attack can be transferred out of an intensive care unit.

(B) Cancer Patient Evaluation

Another specific example is found in cancer-related studies. The major emphasis of nuclear medicine in the field of cancer has moved from the therapeutic use of radioactive materials to the use of novel imaging modalities which permit the early detection and staging of cancers. We are now witnessing the growing use of nuclear medicine in monitoring the therapy of cancer and early discovery of recurrence. Although imaging procedures constitute a valuable adjunct to early diagnosis and staging of cancer, without which the practice of modern oncology could not be conducted, present technology cannot pinpoint very small lesions. Additionally, in some cases the results, while positive, are non-specific. These techniques need to be improved by obtaining more specific radioactive tracers, by pursuing more sophisticated immunologic and biochemical methodology and by developing instruments with better spatial resolution (such as that offered by emission tomographic techniques). Research with radiolabeled monoclonal antibodies is an example of a promising new approach that is being pursued.

Research that would improve the sensitivity and specificity of tumor detection assays promises to have a great impact on patient care. Early and accurate diagnosis is the most important determinant of the proper course of treatment. Early and more accurate decision making will also reduce hospital stay and may reduce lengthy trials with unproven modes of treatment.

Nuclear Medicine procedures also provide a most important means of monitoring therapy in the cancer patient, by providing information on progression or regression of the tumor. This information allows the clinician to continue or modify treatment accordingly. Among the most serious problems in cancer chemotherapy are the serious side effects that antineoplastic agents cause. Such effects can often be more efficiently monitored through the use of nuclear medicine procedures; for example, the cardiotoxic effect of adriamycin, a cancer drug.

(C) Pediatric Nuclear Medicine

Further examples of the improvement in health care from research and development in nuclear medical techniques appear in the area of pediatric medicine.

A nuclear bone scan is a most effective technique in early differentiation of bone infection from soft-tissue infection, disorders which are clinically similar but markedly different in treatment and outcome. A nuclear liver excretion study is the only method short of exploratory surgery to differentiate blocked bile ducts from liver inflammation in jaundiced newborn infants, a patient group that tolerates surgery very poorly.

Non-radioactive tracer studies in children, using enriched carbon-13-labeled metabolic substances such as lactose (milk sugar), quickly and easily identify enzyme deficiencies leading to malabsorption and malnutrition. A wide variety of nutritional substances can be made with non-radioactive tracers of carbon, nitrogen, and oxygen, which are then assayed by using mass spectrometry or nuclear magnetic resonance techniques. Unfortunately both the nutritional substances and the analytic equipment are presently quite expensive to obtain.

(D) Radioimmunoassay

The first Nobel Prize in Medicine to be awarded for Nuclear Medicine research went to an American, Dr. Roslyn Yalow, in 1978. Dr. Yalow, at that time a research scientist with the Veterans Administration, pioneered and helped develop the field of radioimmunoassay, an in vitro nuclear medicine methodology that is unique in that it can detect accurately, and inexpensively almost any substance in biological samples at concentrations as low as a billionth of a milligram! Over 50 companies in the United States now manufacture radioimmunoassay tests that permit physicians to detect specific disease markers, measure blood levels of drugs, and identify pollutants and toxic materials in the biological environment. Detection of "tumor markers" by radio-immunoassay techniques now permits early discovery of primary tumors and metastases before they have become evident clinically. Such tests need to be expanded in scope and refined in specificity.

More examples could be drawn from research already in progress in fields such as mental health, lung disease, renal disease, and alcholism. All of these examples document one salient fact: nuclear medicine procedures are a prime example of rapid technology transfer, where research findings are applied to clinical problems in a very short time. Further research is very likely to yield further benefits, especially since the "pipeline" from the basic laboratory to the practicing physician is already established.

PROMISING AREAS OF RESEARCH

What are some of the areas for which current Nuclear Medicine research funds might properly be used?

a) Expanded radioisotope production efforts: to provide new radioactive materials from accelerators as well as to increase the supply of current radionuclides for radiopharmaceutical development and clinical feasibility studies.

b) Radiopharmaceutical research: to improve understanding of pharmacodynamics and pharmacokinetics; to increase the specificity of tracer uptake; to measure the effects on biodistribution caused by particular chemical groups; to identify and characterize drug interactions; to address problems related to biological effects of environmental pollutants; to achieve reductions in patient dose by developing radiolabeled drugs having more desirable properties.

c) Stable isotope tracer development: to expand the spectrum of metabolically active substances labeled with enriched stable isotopes of carbon, oxygen, and nitrogen; to study a wider variety of clinical applications of stable tracer technology.

d) Nuclear Medicine instrumentation: to improve design and efficiency of detectors; to further develop emission tomography, nuclear magnetic resonance analytics and computer-assisted diagnosis.

SPECIAL NEEDS

The SNM and ACNP would like to call the Committee's attention to a serious deficiency that now exists in the DOE budget in regard to capital equipment needs. This problem has existed for several years but is now reaching a point where this deficiency unless corrected, will severely impair the ability of DOE's Nuclear Medicine research program to effectively pursue its objectives.

In comparable high technology research areas such as high and medium energy physics and nuclear chemistry, the normal percentage of capital equipment funds to operating funds is in the range of 10-20 percent. Nuclear Medicine research requires equipment and instrumentation of similar cost and sophistication; however, during the past several fiscal years the percentage allocated for capital equipment in Nuclear Medicine research has been in the range of 4.0 to 4.6 percent of operating costs.

Fiscal Year	Percentage
1980	4.3
1981	4.6
1982	4.6
1983	4.0

The consequence of these allocations is the present need for massive upgrading of equipment for the basic DOE Nuclear Medicine research program in all of the laboratory facilities.

This problem is not amendable to a one-time remedy particularly in view of current budget constraints, but will require several years of attention. Therefore, we urge the Committee to consider appropriate means for assuring DOE's identification of past deficiencies and future needs in this vitally important area. We feel this should include a policy that will provide 10 to 20 percent of total funding for capital equipment for the Nuclear Medicine research program.

In addition, there is a problem associated with the development of stable isotope production that concerns us. Oak Ridge National Laboratory (ORNL) is the sole domestic source of certain stable isotopes necessary for the production of radio-isotopes used in medical research, diagnosis and treatment. For example; ORNL produces Thallium 203 that is used to generate the Thallium 201 used in heart studies and Tellurium 124 that is used to generate the Iodine 123 for a variety of imaging studies (which reduces the radiation dose to the patient by a factor of 100). Under the existing budget only two of the four banks of separators at ORNL can be operated. Consideration should be given to providing sufficient funds to permit the operation of all four separators so that present needs can be met as well as inventories re-built so that the increasing number of cyclotrons which use such materials can keep pace with increasing demmand from the medical community.

SUMMARY

The members of the American College of Nuclear Physicians and the Society of Nuclear Medicine welcome the opportunity to assist in identifiying research targets that would allow us to capitalize on the Federal dollars invested in research. We urge Congress to continue its support of the basic and applied sciences that nourish nuclear medicine applications development. This support is especially crucial with regard to capital equipment for without up-to-date equipment the research itself cannot take place.

We sincerely thank the Subcommittee for the opportunity to submit this testimony, and are prepared to answer any questions that may arise.

Respectfully submitted,

Gerald N. DeNardo M.D.
Gerald N. DeNardo, M.D.
President
Society of Nuclear Medicine

Jon D. Shoop M.D.
Jon D. Shoop, M.D.
President
American College of Nuclear Physicans

Testimony of Bernard Manowitz, Brookhaven National Laboratory

To the Committee on Science and Technology, U.S. House of Representatives

March 10, 1982

My name is Bernard Manowitz; I am the Chairman of the Department of Energy and Environment at Brookhaven National Laboratory, Upton, New York. At Brookhaven we have been coordinating DOE's oceanographic sciences program for the Northeast and I will concentrate my remarks at those programs with an attempt to put them into the context of the overall DOE oceanographic program.

Introduction

Over the last 300 years, the human population of the northeast coastal zone of the United States has grown from a few Indian settlements to the present megalopolis of 45 million people housed in an almost continuous urban development from Norfolk, Virginia, to Portland, Maine. About 15 million people live just within the coastal counties of the New York Bight from Cape May, New Jersey, to Montauk Point, New York. The annual energy consumption of the northeast United States was 13.6 x 10^{15} BTU in 1975, with only 2.7 x 10^{15} BTU produced in this region; a net energy import of 10.9 x 10^{15} BTU was thus required for the northeast, 60% of which was in the form of oil. A combination of ~200 fossil fuel power plants, 20 nuclear plants in operation or under construction, 12 major oil refineries, and 4 LNG terminals are located within this coastal region through which a great deal of the annual energy supply passes.

During 1974, for example, 1.3 x 10^8 tons of crude petroleum products were imported between Hampton Roads, Virginia, and Portland, Maine, of which 0.4 x 10^8 tons was offloaded in storage tanks or refineries along the Hudson and Raritan Rivers. After processing by society and partial coversion to CO_2, a residue of 3×10^5 tons of oil and grease ($\sim$1%) is usually returned each year to waters of the New York Bight through dumping and waste water running off from the coastal communities in New York and New Jersey. With the grounding of the tanker Argo Merchant on Nantucket Shoals during 15 December 1976, however, 2.7×10^4 tons of #6 fuel oil was released to the coastal ecosystem in a single incident, i.e., 30 times the usual daily discharge of oil to the coastal systems. Similarly, a decade earlier on 16 June 1966, the tanker Texaco Massachusetts rammed another tanker Alva Cape in New York Harbor, a cargo of naptha was discharged, and the ensuing explosion claimed 33 lives on the two ships and nearby tugs.

Major facilities for construction and resupply of nuclear submarines are located at Norfolk, Virginia, at New London, Connecticut, and at Portsmouth, New Hampshire. Power plants, industrial and military complexes, and other energy-related activities emitting pollutants are often sited in coastal areas because of the proximity of cities, transportation, and available cooling water. The increasing utilization of the northeast coastal shelf for oil drilling (e.g., Georges Bank and the Baltimore Canyon), for continued oil transport, for siting of power plants, for various types of planned and inadvertent waste disposal, as well as for food and recreation, requires a careful analysis of the impact of these energy-related activities on the coastal marine ecosystem. The Department of Energy's (DOE) northeast oceanographic program is designed to evaluate this impact, with research conducted at Brookhaven National Laboratory (BNL), Lamont-Doherty Geological Observatory (LDGO), Woods Hole Oceanographic Institution (WHOI), and Yale University.

We now realize that dilution of these effluents by seawater can no longer be considered a simple or permanent removal process within either the open ocean or nearshore waters. In fact, the continental shelf between Cape Hatteras and Georges Bank, in the Mid-Atlantic Bight, is subject to both atmospheric and coastal input of pollutants in the form of present releases of heavy metals, synthetic chemicals, petroleum hydrocarbons, and radio-nuclides, as well as in the form of deposits of past urban wastes. During 1951-1967, about 34,000 containers of radioactive waste (including the pressure vessel of the Seawolf reactor) were dumped off the northeast coast, and the tragic loss of the Thresher occurred only 300 km off Boston in 1963. Acute and chronic pollution problems of the coastal zone thus result both from improper management of production and waste disposal procedures and from accidents that are endemic to most of man's endeavors. However, the economic impact of totally clean procedures, combined with current technological and manpower limitations, dictate that some environmental pollution must be associated with energy production and consumption. The impact of long-term, low level pollutants in the atmosphere, biosphere and hydrosphere is not well known nor is it easily predictable for many kinds of pollutants.

To put the program into a broader and more historical context, beginning in the 1950's with studies on processes that distributed radioactive fallout through the oceans and into the food chain, the AEC environmental research program pioneered the use of natural and artificial radionuclides to identify major sinks and reservoirs of materials, to determine movement and mixing rates of water masses, and flushing rates along the shelf.

In the early 1970's, fallout had subsided, and the new concern of the AEC was for radioactivity from shore-based nuclear plants, and the possibility of marine contamination from offshore nuclear power plants. In response, the oceanography program was moved into shallow coastal waters, where pollution problems are much greater. Boundary areas in the ocean are always productive, and the coastal zone with interfaces of land with water, and seawater with freshwater are especially productive and subject to damage from pollutants. At the same time, there is less water available in the shallow coastal waters to dilute the pollutants which flow into this area.

To attack the complex problems on the shelf more effectively, a program was initiated in the mid-1970's to create regional research teams made up of biologists, chemists, and physical oceanographers because interdisciplinary teams would more rapidly and effectively unravel the problems by working together. This concept is now operational in the New York Bight, the Southeast, California, and Northwest. A research team for the Gulf of Mexico has been postulated for several years, but has not yet been initiated. About 75% of the funds go to university contractors working together under regional coordinators, often in cooperation with other Government agencies.

The Department of Energy is gaining understanding of the cycling and behavior of energy-induced pollutants in the coastal zone from its long experience and by its focus on processes through the use of regional teams using radioactive tracers in the ocean, and limited laboratory studies. This long-term approach, to study continental shelf processes, is unique among government agencies with research efforts in oceanography, but it has been an important element in giving an understanding of the dynamics of the coastal areas.

Such a multi-institutional, interdisciplinary research program will provide important information needed for future decisions on the extent to which the continental ocean can be safely used for exploitation and disposal of energy products.

The siting of energy production and transportation facilities has economic and social consequences beyond those traditionally associated with industrial concerns (i.e., ready access to markets and plant operation safety factors). Any pristine site reacts to the introduction of a new structure (or process) by changing over periods from a few seconds to many years. Some short-term changes can be recognized and controlled by modern engineering methods; other short-term changes, because of our lack of knowledge of the complexity of natural processes, are much more difficult to measure, predict and deal with. Long-term changes and their effects are most difficult to recognize and assess. The nature and range of natural processes operating at any site and the extent and time scale of the interaction of foreign structure (or processes) needs to be known before we can evaluate the consequences of continuous, slow adjustments or catastrophic changes due to rare events. It needs to be emphasized, however, that all changes are not necessarily deleterious. It is equally damaging for government regulations to stifle energy production and possible benign effects, as it is to have regulations missing or applied too late to avoid impacts on our health and well-being.

Approach

The fundamental objective of DOE-supported research in northeast coastal oceanography is to develop knowledge and understanding of the coastal ocean to the point where the effects of energy-related activities can be confidently assessed, with prediction of their future impact. Energy-related activities having potential adverse impact on the coastal zone or on the waters of the continental shelves include electricity generation at coastal and offshore sites, especially by fossil and nuclear means, the introduction of pollutants from refineries and power plants on the coastal estuaries, and the production and transportation of petroleum. The possibility of accidents in the course of such operations overshadows all other environmental impacts. While many secondary problems exist, such as the ingestion of fish larvae into cooling water pumps, or the slight thermal effect of heated discharges on biota, major delays in nuclear power plant construction, superport development, or offshore drilling are almost entirely due to uncertainty regarding the consequences of accidental releases of radioactivity or heavy metals or to the fear of oil spills. Inadequacy in our knowledge of key physical, chemical and biological transport processes in the coastal ocean - from dispersal at the site of pollutant injection and passage up the coastal food web to the ultimate transfer to man - is responsible for the uncertainty.

Research support by DOE for studies of the coastal ocean between Cape Hatteras and Georges Bank is concentrated in a few laboratories; Woods Hole Oceanographic Institute, Yale University, Lamont Dougherty Geological Observatory and Brookhaven National Laboratory. Each laboratory contributes to the overall goal, although the focus differs from one laboratory to another and among different disciplinary groups. A concise general description of each disciplinary group's contribution follows:

The physical oceanography groups at WHOI under Dr. Gabriel Csanady, at LDGO under Dr. Arnold Gordon, and at BNL under Dr. Thomas Hopkins conduct theoretical and observational studies of the physics of the continental shelf circulation, the mechanics of the coastal boundary layer, and on mass exchange mechanisms between coastal waters and the deep sea. Using CTD, XBT, moored current meter and thermister chain measurements, they are studying the dispersive properties of nearshore waters within 10 km of the coast, the variability of exchange at the shelf/slope frontal zone, and the hydrographic characteristics of the mid-shelf cold pool from the Gulf of Maine to Cape Hatteras. Numerical and analytical models have been developed for use both in design of the field experimentation and in analysis of the diverse data sets.

The chemical oceanography groups at WHOI under Drs. Derek Spencer and Vaughn Bowen, at Yale under Dr. Karl Turekian, at BNL under Drs. Terry Whitledge and Eugene Premuzic, and at LDGO under Drs. Pierre Biscaye and Yuau Hui Li conduct theoretical and observational studies of the chemical processes governing the formation, sedimentation, degradation, transport, and resuspension of marine particulate matter from coastal estuaries to the pper slope. Using radioisotopes, nutrient species, and stable isotopes as tracers of water mass origin and mixing, of sediment deposition, and of bioturbation, they are studying the introduction, transport, and removal of various kinds of pollutants (i.e., organic and inorganic, dissolved and particulate). Models have been developed for both near-bottom and cross-pycnocline mixing, trace metal recycling in the sediments, nitrogen cycles, and removal of reactive metals at the continental margins.

The biological oceanography groups at BNL under Drs. John Walsh, Tom Malone, Paul Falkowski, Sharon Smith, Julio Vidal, and Gilbert Rowe, at WHOI under Drs. John Teal and John Farrington and at LDGO under Dr. Hugh Ducklow conduct theoretical and observational studies of zooplankton, bacterial and benthos growth and metabolism in relation to phytoplankton production as effected by pollutant organics and nutrient discharge from both the northeast estuaries and the shelf-break. They are studying the rates of turnover and accumulation of carbon in the coastal food web and, therefore, the rates at which particle related pollutants are potentially made available to man. Emphasis will continue on phytoplankton-zooplankton interaction because of their importance as transfer mechanisms to higher levels of the pelagic food web. Benthic macrofauna will also be studied because they are sessile for the most part as adults and long-lived, thereby concentrating pollutants, and are the primary consumers of the demersal food web. Modeling studies suggest that sediment depocenters are the ultimate sink of the energy-related particulates on the northeast shelf, and we thus intend to also identify those sinks and quantify such reservoirs for particular elements, with emphasis on carbon and nitrogen recycling by bacterial, benthic, and zooplankton populations.

Future Plans

During the past year or two, common recognition began to emerge among the different laboratories and disciplinary groups of a key scientific issue that must be tackled head-on if progress in understanding is to proceed at its recent rapid pace. This issue is the problem of cross-shelf exchange, in a broad sense, from estuaries to the continental slope, for liquid and particulate phase materials, including the many intricate transformation processes involving living organisms and suspended or deposited particles. A question of overriding importance is, where the principal oceanic "sinks" are for various chemical species or for particulate matter, i.e., where and by what processes these species or particles are removed from active participation in marine life processes. A variety of arguments, physical, geochemical and biological, have suggested the principal hypothesis underlying the experimental design of the Shelf Edge Exchange Processes (SEEP) program, which is that the upper continental slope sediments constitute a major sink for many undesirable byproducts of human activities which enter the ocean by whatever route.

A number of laboratories and disciplinary groups have begun independently to concentrate their work on various problems of cross-shelf exchange. Agreement among the several DOE-funded laboratories in the northeast has now been reached to coordinate these activities and to engage in a joint, multidisciplinary program of research on cross-shelf exchange, consisting of three major field programs in FY 1983-84 (SEEP-I), 1986-87 (SEEP-II) and 1989-90 (SEEP-III), located respectively south of Martha's Vineyard, Delaware-New Jersey, and Maryland-Virginia. The field efforts will be supported by analytical work, data evaluation and theoretical model development. During FY 1982, DOE funds would be devoted to both analysis of present data and purchase of equipment for the first BNL, LDGO, Yale, WHOI joint experiment, SEEP-I (Shelf Edge Exchange Processes-I), level funding for the program has been maintained on the FY 1983 budget so that the major objectives for that time period will be attainable.

Accomplishments

The knowledge base developed in the DOE supported program has already been applied by a wide community of users. Some examples of application by the Brookhaven Oceanographic Sciences Division are as follows:

1. The anoxic event of 1976 off New Jersey which killed both finfish and shellfish was analyzed for both natural and manmade causes. Natural events were determined to be the primary cause of the anoxia.

2. A mathematical model was developed which was able to predict the speed and direction of the Argo Merchant oil spill that occurred near Georges Bank. The model was also used successfully to predict the path of floatable releases from sanitation facilities that were fouling the Long Island beaches in 1976.

3. An analysis of coastal sediment deposits has indicated that a significant fraction of primary production is exported from the continental shelves. This organic carbon is sequestered on the continental slope and appears to be the "missing" carbon in CO_2 cycle models.

4. The upper slope region of the U.S. continental shelf has also been identified as a repository for energy related by-products such as those released from fossil fuel combustion.

5. The environmental effects of Ocean Thermal Energy Conversion (OTEC) plants were assessed with respect to siting locations.

6. Cooperative field programs with NOAA/NMFS on the processes responsible for larval fish survival and with NASA on remote sensing of food items for fish and zooplankton have strengthened the concepts of fisheries management and prediction of successful spawning of food fish populations.

Mr. Chairman and Members of the Subcommittee:

I appreciate the opportunity to present testimony concerning the Department of Energy's environmental research program. My name is Frank B. Golley, and I am a Research Professor in Ecology at the University of Georgia, Institute of Ecology. I have been associated with programs of the Department of Energy and its predecessor agencies AEC and ERDA since 1958. I was the first director of the Savannah River Ecology Laboratory at the DOE Savannah River Plant in Aiken, South Carolina. And in the last several years, I served as Division Director of Environmental Biology in the National Science Foundation. While this background will give my testimony a bias toward the nuclear aspects of the Departments' programs, the problems associated with the nuclear industry actually are excellent examples of the generic problems associated with energy industries as a whole. I will focus on three topics: 1) The nature of the Department of Energy environmental research program as it evolved from its beginning in the AEC, 2) Future research needs and 3) The relationships of the Department's environmental research program to other environmental research in the federal government, especially in the NSF.

The Environmental Research Program

As is often the case, we must begin by defining our terms. I am using environmental research to mean mainly ecological research where studies focus on the response of living organisms to disturbances in their environment. Such studies may also be labelled environmental biology, although environmental biology also includes investigation of taxonomic status and the national history of organisms. I am not including within this discussion what is called environmental science research which focuses on the physical nature of the atmosphere, oceans and the earth.

The Department of Energy's environmental research program can be divided into efforts which establish the basis for future action and other programs that focus on specific needs. While we might classify the first as basic and the second as applied, both types of programs (as do all good research programs) contain both basic and applied elements within a single effort. In my view a notable example of the first type of program has involved the long term and on-going study of ecological systems or ecosystems. An ecosystem is a natural system composed of the plants, animals, microrganisms, climate, soils and water at a specific place. For example, a forest or a lake is an ecosystem. The term "ecosystem" expresses in a technical way the common sense view that everything is connected to everything else. We find the word used widely today in technical reports, the popular press and in governmental regulations. Yet, merely twenty-five years ago it was a code word used by a small group of ecologists who were investigating ecological systems in the United States.

In those days the AEC was faced with predicting where radioactive materials produced by weapons testing and industry might move and concentrate. As data accumulated, the results frequntly surprised us--recall, for example, that caribou in Alaska were found to contain unusually and unexpectedly high amounts of radioactivity. It took a great deal of research to determine these large mammals were accumulating fallout products from the lichens they consumed as foods, and that lichens were particularly efficient accumulators of chemical materials in their environment. Because of such needs, the AEC supported studies of ecosystems throughout the U.S., at its major production installations, such as the Savannah River Plant, Oak Ridge National Laboratory, and at Hanford and elsewhere. The concept of an ecosystem was literally made operational and useful through this AEC sponsored research. This investment has paid large dividends not only to the Department of Energy, but to other agencies of federal and local governments concerned with land and water resources and their management.

Ecosystems are exceptionally complex entities. They contain thousands of species of plants, animals and microorganisms which interact in a variety of ways. This means that an ecosystem such as a forest is much more complicated than the largest computer constructed by man. We do not know one complex ecosystem well enough that we could reconstruct it in the way that we construct a machine. Since we depend upon ecosystems for all of our biological needs--air, water, food, shelter--our ignorance of ecosystem structure and function is reason enough for research and for careful, sensitive management.

This is especially true in the area of nuclear industry. This industry produces chemical materials which release energy through radioactive decay. Such energy can be damaging, even lethal, to man and other forms of life. A given chemical retains its dangerous radioactivity only for a specific time but some of the materials produced industrially will be dangerous to man and his environment for thousands of years. When you recognize that such a time span exceeds that period from the time of Christ to the present, you realize the urgent need to understand how these materials behave. The urgency is compounded by the fact that the United States is not the only nation releasing radioisotopes to the environment, yet we are linked to these other nations through the currents of air and water that tie the biosphere together.

The Department of Energy and its predecessor agencies have consistently supported studies in radioisotope transfer and storage. Through this investment we understand that organisms in ecosystems form chains of feeding relationships and that these chains are frequently limited to three or four links. A chemical, such as a radioisotope, is transferred up a food chain, concentrating in the various levels and being passed to the next level through feeding and predation. We have some understanding of the rates of turnover within organisms and how active organisms turn over chemicals at a more rapid rate than inactive organisms. We have also shown that such rates of radioactive turnover for free living animals may differ significantly from those in cage-confined animals, such as the white mouse. In other words, we have the rudiments of understanding required to predict where and how much radioactive material will move in an environment. We know little about specific environments, but our research experience is adequate for design of efficient research programs addressed at specific needs.

An example of another area of research focused on a specific problem concerns the global carbon studies. We know without question that the level of carbon dioxide in the atmosphere is increasing steadily. We do not know exactly why this build-up has occurred, nor what will be the consequences of a global carbon increase. The Department of Energy has sponsored a variety of important research efforts focused on this problem. These efforts are housed in a special unit concerned with CO_2 and also in the Ecological Research Division which supports research on the basic phenomena underlying the issue. The studies have employed the most up to date computer modelling and statistical methods and have involved some of the best minds worldwide. Nevertheless, our knowledge of the carbon cycle of earth is incomplete, and it is extremely difficult to predict with confidence impacts of various scenarios of global carbon increase or decrease.

As an example of the questions in this area of research, we have reasonably good estimates of carbon in living vegetation in many parts of the world, but we do not know the content of carbon in the biomass of tropical forests and grasslands with comparable confidence. Worse, we have relatively poor confidence in our estimates of carbon in soil, yet we estimate that the carbon stored in the soil is greater than that in all the living vegetation on earth. Soil carbon in disturbed ecosystems is thought to be only one-third that in natural, undisturbed ecosystems, but we do not know what proportion of the natural ecosystems have been disturbed sufficiently so that soil carbon levels have declined. We also are unsure of the capacity of the ocean to take up and release carbon dioxide. And so on through a series of fundamental environmental questions. Yet, the increase in global carbon levels is said to have such serious consequences that we should take national initiatives to control carbon release. The research investment here has probably not been adequate, yet, again, the studies that have been carried out provide us with adequate knowledge to efficiently design further work which will provide the basis for decision making.

The research programs of the Department of Energy and its predecessor agencies have furnished the country a strong data base in radioecology and the environmental impacts of energy generation. Equally importantly it has produced a cadre of research workers with deep experience in these problem areas. Further, these workers have built up a series of long term research programs where the background detail essential to ecosystem research is being collected. These people and sites are a national resource, which if allowed to decline or be lost due to budgetary reasons could be replaced only with great difficulty and with large costs in money and time. The situation is made more acute by the fact that depressed funding conditions do not attract young scientists to the field, we are potentially faced with an aging and declining population of environmental professionals able to do research on environmental problems associated with energy industries. To lose this investment is terribly serious since the U.S. has no choice but to maintain a research effort in this area.

Research Needs

Let me turn now to future needs. I will be brief and write in general terms rather than cite specific project requirements. Ecosystems vary greatly in time and space, and we must understand their capacity to process products of energy industries at a variety of scales. The current set of less than a dozen Department of Energy National Environmental Research Parks (NERPS) is clearly inadequate to give the spread required for the nation. Research at such sites (which include, as you know, most of the nuclear production facilities of the USA) must have continuity so that long-term changes in the environment and the impacts of regulation and management can be monitored and studied. The ecological research must be freed of year to year stop and go funding, otherwise we do good work but only on short-term limited problems. The difficult long-term, large-scale needs are unmet and the country suffers since while we can always mount emergency efforts, we cannot create retrospective data.

A further need for energy-related environmental research is to build sufficient depth of knowledge in key ecosystems so that we can truly understand chemical and biological interactions. For example, we know a great deal about higher plants, insects, and vertebrates in terrestrial communities. In contrast, we know very little about microorganisms. Even though almost 90% of the organic matter produced in those communities passes through food chains in which bacteria and fungi play a key role, we are generally ignorant of the actual processes controlled by these organisms. This area of research is just beginning to flower; it is fundamental to our understanding of the ecology of natural and disturbed systems, and promises large practical benefits.

Relationships with Other Agencies

Finally, I will make a few brief comments about the interconnection of the environmental programs of the Department of Energy and other federal agencies. I have completed a preliminary study of federal funding over the last ten years--the Decade of the Environment. I describe these data as preliminary because my classification of research at a finer scale than that routinely used in agencies has not been checked by them for accuracy. I feel, however, that while the absolute numbers may change slightly, the data provide us a correct picture of the general relationships. The data come mainly from NSF report 79-318. As I mentioned above prior to the late 1960s the AEC and ERDA were a major source of support for ecological research. Which agencies are the major support of ecology and environmental biology today?

If we base our analysis of the year 1979, the last year of the Decade of the Environment, the data show that NSF is the major support of basic environmental biology research (which includes systematic biology, population biology, ecology and ecosystem studies) (See Table 1 for 1979 which reflects reasonably well today's patterns). The budget for these activities in NSF is in the region of $40 million annually. The Department of Energy is second, spending about $17 million annually for basic ecological research. In contrast, in applied environmental biology or ecology research, EPA has been the major support (about $75 million in 1979), followed by the Departments of Agriculture and Energy.

Table 2 describes the trend in support of ecological research for the Department of Energy from 1973 to 1982. These data suggest strongly that the Department of Energy's role in supporting research in these areas has declined from a position of great importance and continues to decline today. There is no question in my mind that continued investment equaling or exceeding the inflation rate is essential to maintain these research programs.

While NSF has taken over some of the responsibilities for basic ecological research from the Department of Energy, especially in the area of ecosystem studies, the Department alone has special concern for the radioecology of terrestrial, freshwater and marine ecosystems and for research on the impacts of energy generation and use. These are such important and potentially dangerous areas of activity and are the focus of such large public concern, that it seems inconceivable that we would reduce, let alone dismantle, our research programs on these topics. The research supported by the various agencies links together in an increased understanding of our nation's ecosystems, but the peculiar focus and responsibilities of each is not covered by another.

Finally, I should add that there are potential areas of cooperation that will yield reward. An example is in the building of networks of research sites where we can better understand the geographical and temporal spread of key ecological processes. The Department of Energy has its National Environmental Research Parks where this work is going on; NSF has initiated a long-term ecological research program which includes sites managed by the U.S. Forest Service and the U.S. National Park Service. These and other similar areas collectively form a network of ecological reserves which is a national resource. Hopefully, through such networks we will be able to determine if the nation's environment remains healthy, is deteriorating or is improving. There are other areas of cooperation that cannot be discussed because of time. Let me assure you that cooperation occurs readily between agency people concerned with the environment.

In conclusion, let me thank you again for this opportunity. I have traced the development of the environmental research program of the Department of Energy from its inception in the AEC, shown how this program has contributed significantly to our understanding of the nation's environment and concluded that investment in this area will continue to yield substantial benefit. I caution that loss of this program will be serious because new research cadres cannot be readily trained and research sites reestablished. And, there is no question in my mind that this nation will require greatly increased knowledge of radioecology and environmental impacts of energy generation in the future.

Table 1. Statistics obtained mainly from NSF 79-318 on Support of Environmental Biology in 1979 using Agency Classification (Thousands of Dollars)[1]

Agency and Subdivision	Applied	Basic
Total, all agencies	148,286	81,338
Departments		
Department of Agriculture, Total	37,080	10,954
Forest Service	31,484	7,494
Science & Education Administration Agricultural Research	5,596	3,460
Department of Defense, Total	1,984	2,608
Department of the Army	1,290	162
Department of the Navy	62	915
Department of the Air Force	424	1,531
Defense Agencies	-	-
Defense Civil Preparedness Agency	208	-
Department of Energy[2]	17,200	17,200
Department of the Interior, Total	16,622	-
Bureau of Land Management	100	-
National Park Service	4,122	-
U.S. Fish & Wildlife Service	12,400	-
Environmental Protection Agency	75,400	4,022
National Science Foundation	-	40,935
Smithsonian Institution	-	9,894

[1] Data from Tables C-18, C-36, and C-56 in NSF 79-318.

[2] Data obtained from Department of Energy, applied and basic split in environmental-ecological research is approximately 50/50.

Table 2. Recent Trends in federal support of ecological research in the Department of Energy. Data are based upon classification of research in the Office of Health and Environmental Research.

Year	Current Dollars (millions)*
1973	19.2
1974	21.2
1975	32.7
1976	45.1
1977	46.7
1978	48.0
1979	34.4
1980	35.2
1981	30.2

*Includes basic and applied research in Ecological Research Division.